Class 82
2R
82-117

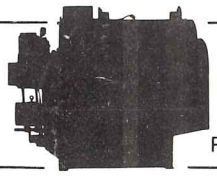
DAVENPORT PRINCIPLES

...BASIC INSTRUCTION

A series of six articles published in

AUTOMATIC MACHINING, 1975

Davenport



DAVENPORT MACHINE TOOL DIVISION
DOVER CORPORATION
P.O. Box 228 • Rochester, N.Y. 14601 • (716) 235-4545

82/117

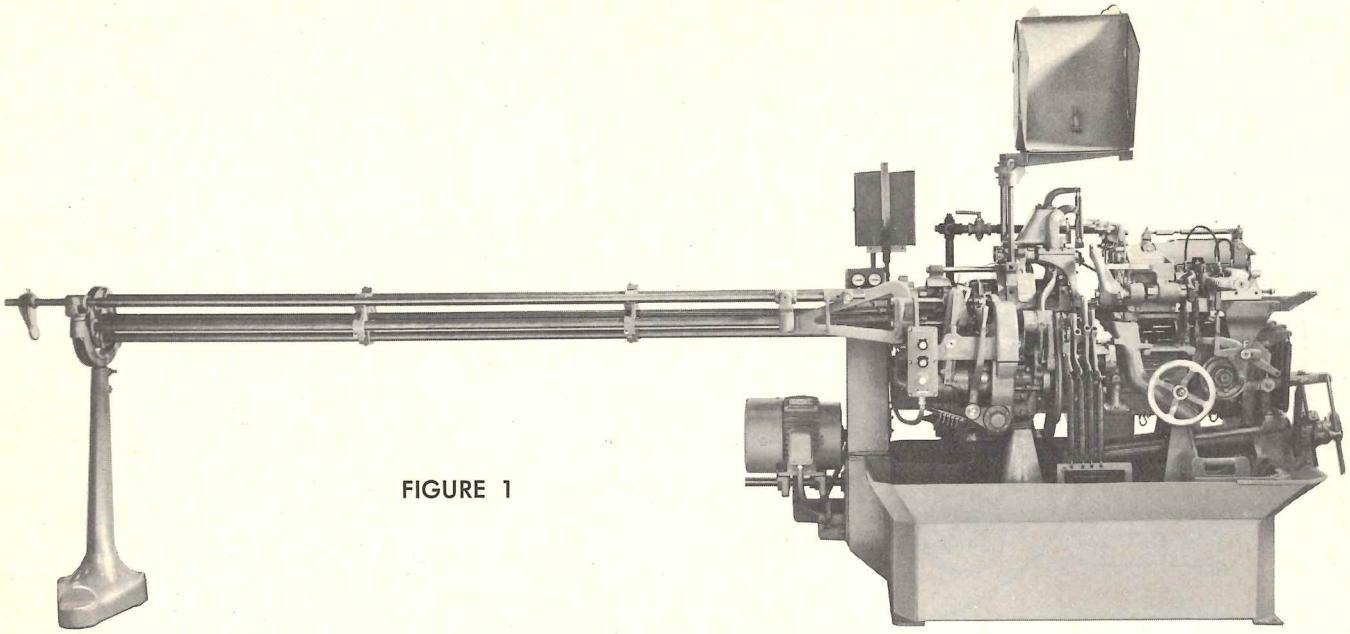


FIGURE 1

DAVENPORT PRINCIPLES

Basic Instruction: PART 1

WITHIN the screw machine industry there are four basic types of bar automatics: Single-Spindle, Swiss, Multiple-Spindle, and Davenport.

The last-named is in a class by itself because, though technically a "multiple," it has five spindles instead of the usual four, six or eight. To greater extent than any of the others it offers individual motion for every tool. Moreover, it is one of the fastest automatic screw machines available, having the ability to complete rather complex workpieces at rates to 75 per minute.

In deference to exceptionally rapid productivity, the Davenport Model B Automatic *(Figure 1)* is also one of the lightest multiples, weighing less than 5,000 pounds fully equipped.

Because of these differences, the setting up and operating of Davenports is recognized as a separate skill, almost always in demand.

No amount of reading or classroom study can teach techniques which must be learned by actual practice. For that reason, the aim of this and five succeeding articles is not to produce instant Davenport operators and setup men. Instead, it is intended to give background information for faster assimilation of on-job instruction.

With no further preamble, let us begin.

The machine shown in Figure 1 was developed about 1907 by William Simeon Davenport. Since 1919, it has been built at Rochester, N.Y., by Davenport Machine Tool Co., now a division of Dover Corp.

Unlike most other builders, Davenport has not produced a variety of machine sizes. Except for periodic improvements in structural materials, and inclusion of newly developed attachments, the Model B pictured is essentially similar in both capacity and design to the 7,500-plus Davenports in use here and abroad, including some DA-2 *(½-inch)* machines built in New Bedford, Mass., by Morse Twist Drill Co., for Mr. Davenport prior to 1919.

The standard Model B, known as a "75 cycle" machine because it can produce 75 parts per minute, is designed to handle bar stock up to 9/16-inch round, ½-inch hexagonal, or ⅜-inch square. Spindles can be geared to rotate at speeds between 500 and 4,500 r p.m. Bar stock may be fed three inches at any one time, and workpieces can be turned a distance of 2½ inches in one tool stroke. The machine has an "idle constant" of .4-second; more on this important factor later.

The other Davenport which may be encountered is an oversize version of the same machine, modified to handle bars up to 13/16-inch round, ⅝-inch hex or ½-inch square. This model, due to oversize capacity, in some instances has .5-second idle time, and top spindle speed of 2400 r.p.m.

Construction

Like other multiples, the Davenport has an indexable Spindle Carrier which transfers a bar of work material from one tooling station to the next until the workpiece is completed and cut from the bar. Carrier index is counterclockwise, as can be seen in Figure 2, which views spindles from the front, or collet end.

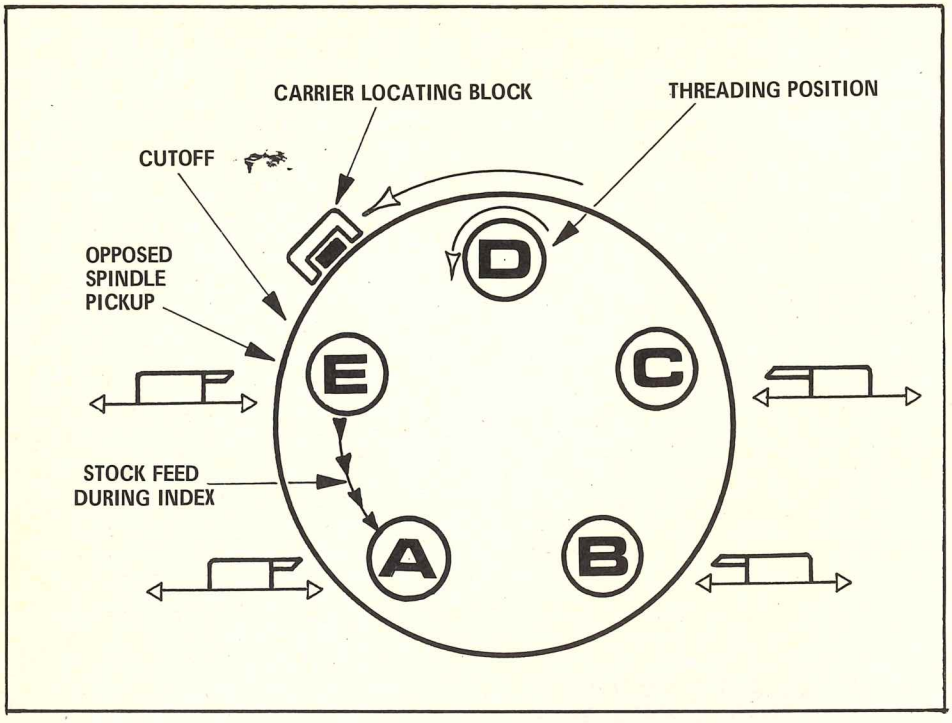


FIGURE 2

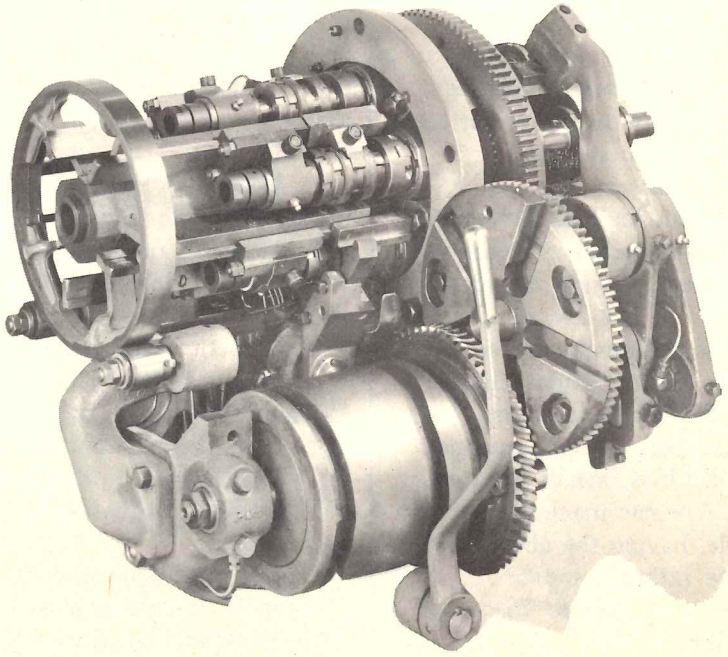
FIGURE 3

Unlike most multiples which assign numerals to stations, Davenport labels positions with letters. Final Station E is used for cutting off a finished part *(and for back end work if required.)* The bar is fed *during index* to Station A, by a crank-adjustable system which permits fed length to be held with use of a stock stop. As shown in Figure 2, the machine has four cross slides, with provision for mounting a fifth in topmost Station D if required. Normally, however, Station C or D is reserved for tapping or O.D. threading operations.

The spindle carrier *(Figure 3)* differs from other multiples in one important respect. Instead of the traditional center drive gear, spindles are driven by an encircling ring gear having teeth inside and out.

Inside teeth mate with and surround teeth on gears fixed to the back end of all five spindles. The fit is such that the ring gear needs no other support; its contact with the five spindle gears provides a rolling five-point bearing.

Teeth on the outside of the Spindle Ring Gear mate with a drive gear which, through "change gears," allows speed to be varied.



Power for all motions of the machine, including spindle rotation is from a 7½ h.p. motor in the base at the headstock end.

By eliminating a central spindle drive gear, Davenport avoids the necessity for a "stem" through the endworking tool zone. This permits five "tool spindles" to be arranged for independent actuation from five cams mounted on a cam carrier shaft running crosswise along the right hand end of the machine.

Directly above these cams are five quadrant-type levers which control the stroke of end-moving, tool-holding spindles for each of five work spindles. Similar linkage levers actuate the four cross slides. Positions of the nine cams needed for these functions are shown in Figure 4. Note that cams for feeding stock, operating the collet and locating the carrier are at the end of the front cam shaft.

Quadrant System

On conventional multi-spindle screw machines, tools are mounted on a slide which advances and withdraws under control of one tool slide cam. This requires all tools to have the same working stroke and feed per revolution. If longer throw is needed *(say, for a reaming operation)* an auxiliary slide is mounted at that station to provide the extra motion.

The Davenport Model B departs from this principle by using what amount to "auxiliary" spindles as standard equipment in all end-working positions. Since each tool spindle is actuated by a separate cam, the stroke *(and hence feed per revolution)* at that station is independent of stroke and feed in all others.

The price paid for this feature normally would be the need to mount five specially designed cams for endworking operations, and another four for cross slide work. However, a quadrant system, illustarted in Figure 5, allows a variety of throws to be obtained from nominal-rise cams.

To explain, suppose it is known that work will require a cam throw of about one-inch at a given station and a cam with that throw is mounted. By adjusting the block either side of a "1" setting *(where tool stroke equals cam rise)* it is possible to obtain from the one-inch cam a throw as short as .800-inch, or as long as 1.200-inches.

In upcoming installments of this series a great deal more will be given as to how this feature influences cycle time and feed-per-rev. Here, however, it may be well to make these points:

First, on a Davenport, all slides retract under spring tension. Additionally, the front cross slide has positive return. Therefore, "guard" cams are not used in eight of the nine positions.

Next, cams are graduated in hundredths, possibly because William Davenport was a design engineer at Brown & Sharpe before leaving to develop his own machine. *(Single spindle screw*

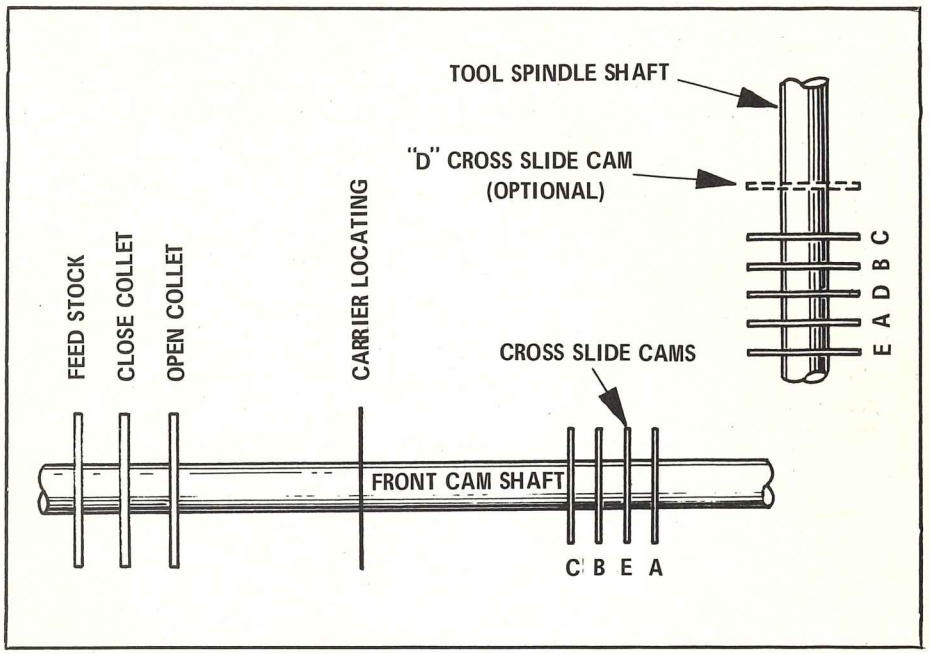
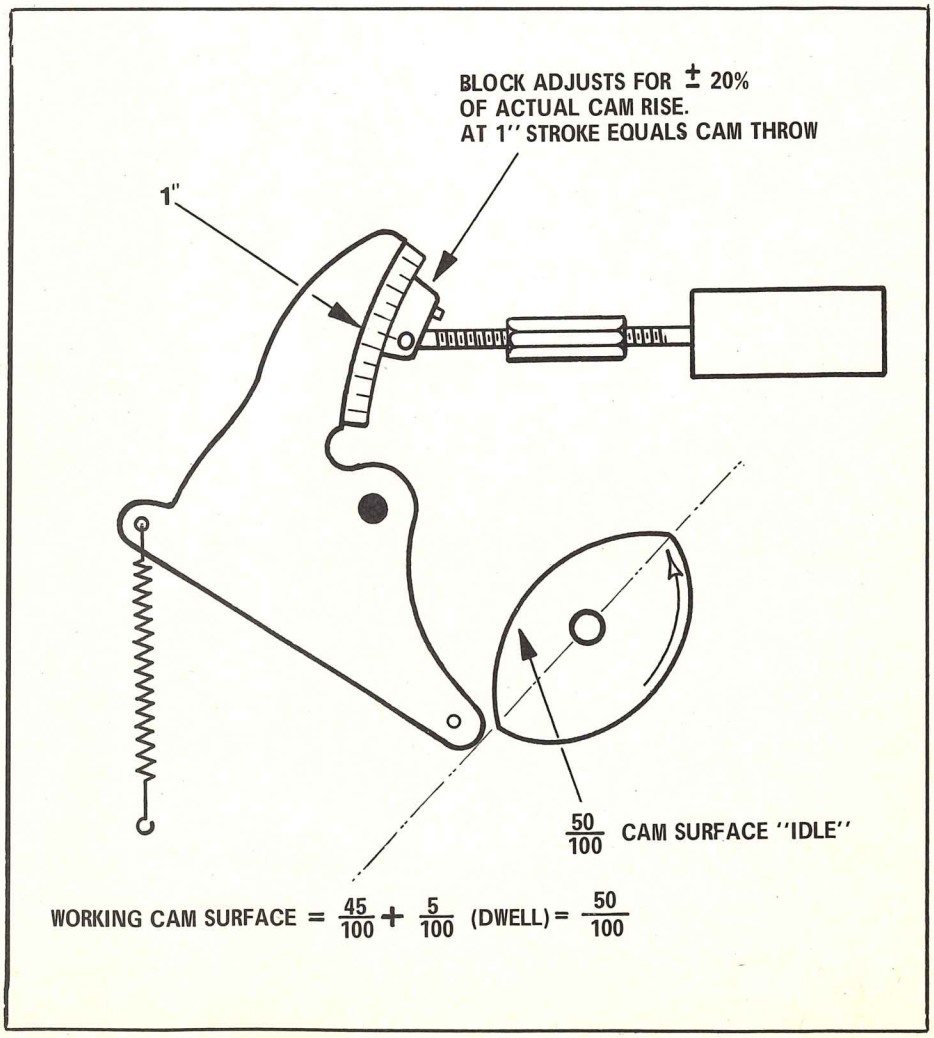


FIGURE 4

FIGURE 5


BLOCK ADJUSTS FOR ± 20%
OF ACTUAL CAM RISE.
AT 1" STROKE EQUALS CAM THROW
1"
50/100 CAM SURFACE "IDLE"
WORKING CAM SURFACE = 45/100 + 5/100 (DWELL) = 50/100

machines, except for sliding headstock Swiss types, use hundredths for graduation of cams while all domestic-built multiples, other than Davenport, designate cam rotation in degrees.)

The importance of understanding the method used is that, on Davenports, cam graduations equate to percent of camshaft rotation.

As stated on Figure 5, cutting operations usually occur in 45/100ths of cam space which, with a final 5/100ths added for tool dwell, accounts for exactly half the available surface. Since a completed workpiece is cut off each time the cam shafts make on complete revolution *(one "cycle")*, the Davenport principle allots half the cam circle to cutting operations accomplished at a feed rate, and the other 50 percent to non-cutting machine motions such as withdrawing and advancing tools, feeding stock, and indexing the carrier.

Change gears are provided for varying the speed of camshaft rotation during the 50 hundredths of cutting action. The "idle" or non-cutting functions occurring in the other 50 hundredths are accomplished with the camshaft revolving "in high" at a *fixed* rate. Therefore, while the cutting portion of the cycle can be varied, the idle portion cannot.

As mentioned at the start, the standard Model B Davenport has an "idle constant" of 2/5-second. The next installment of this series will deal with the effect of feed and speed on total cycle time. ■

DAVENPORT PRINCIPLES

Basic Instruction: PART 2

THE PREVIOUS installment of this series mentioned ways in which Davenport automatics differ from other other multi-spindle types. It was stated that five work spindles are driven by a surrounding ring gear, thereby eliminating a central drive shaft through the tool zone and making it possible to individually cam five endworking "tool spindles." Part 1 of the series also pointed out that Davenport cams are graduated into hundredths, rather than degrees, and that one-half, or 50 hundredths of cam circle are allotted for non-cutting "idle time" functions accomplished at a constant rate of camshaft rotation.

This installment will deal with the other 50 hundredths during which all cutting operations must be accomplished. Figure 6 shows power trains for the standard Davenport Model B automatic. Figures in parenthesis on the diagram are for the oversize 60-cycle model. The view *(somewhat rearranged for clarity)* is from above and behind the machine.

Study of Figure 6 will indicate power is distributed through three basic systems all originating at a 7½ h.p. motor, bottom-center. A chain on this motor drives the 36-tooth sprocket directly above it, from which a shaft, leading to reader's right, allows spindle speeds to be varied by means of change gears in the machine's headstock end. The output side of this variable speed transmission arrangement drives the surrounding ring gear which rotates all five work spindles at selected rate of speed. Once the change gears have been chosen and mounted, "spindle r.p.m." becomes a factor in cycle time calculation, as will be seen.

The same 36-tooth sprocket also powers a face clutch *(directly below it in Figure 6)* whose output shaft leads leftward to an 80—40—tooth gear combination that doubles shaft speed, and to another 32—60—tooth gear set just beyond. The first set, it will be seen, connects with a "high speed clutch" on the bottom-most shaft; the second set leads to feed change gears at left end of Figure 6.

The result is a split in the feed train which allows rapid/constant camshaft rotation by engaging the "high speed clutch" on the bottom shaft, or a variable rate of camshaft rotation by disengaging the high speed clutch and allowing power to flow through change gears via an "over-running" *(ratchet-style)* slow speed clutch shown in the hub of an inside feed gear.

With the high speed clutch engaged, *all* camshafts on the machine rotate at 75 r.p.m. for the standard Model B, or 60 r.p.m. for the oversize version. This rate of rotation during one-half, or 50 hundredths of each camshaft "cycle," requires .4-second for the standard machine, or .5-second for the oversize version. Since these "idle constants" directly affect total cycle time, it may be well at this point to warm up arithmetically by looking at how they are derived.

The 75 r.p.m. camshaft speed just mentioned is the result of feeding 750 r.p.m. through a 10:1 worm reduction seen just to the left of the high speed clutch. Therefore, on the Model B Standard:

$$\frac{60}{75} = .8 \text{ sec. per rev.}$$

$$.8 \times 50/100 = .4 \text{ sec. idle time}$$

Cam shaft rotation on the oversize machine *(600 r.p.m.)* is likewise reduced 10:1. Therefore:

$$\frac{60}{60} = 1 \text{ sec/rev.}$$

$$1 \times 50/100 = .5 \text{ sec. idle}$$

Throw vs. Feed

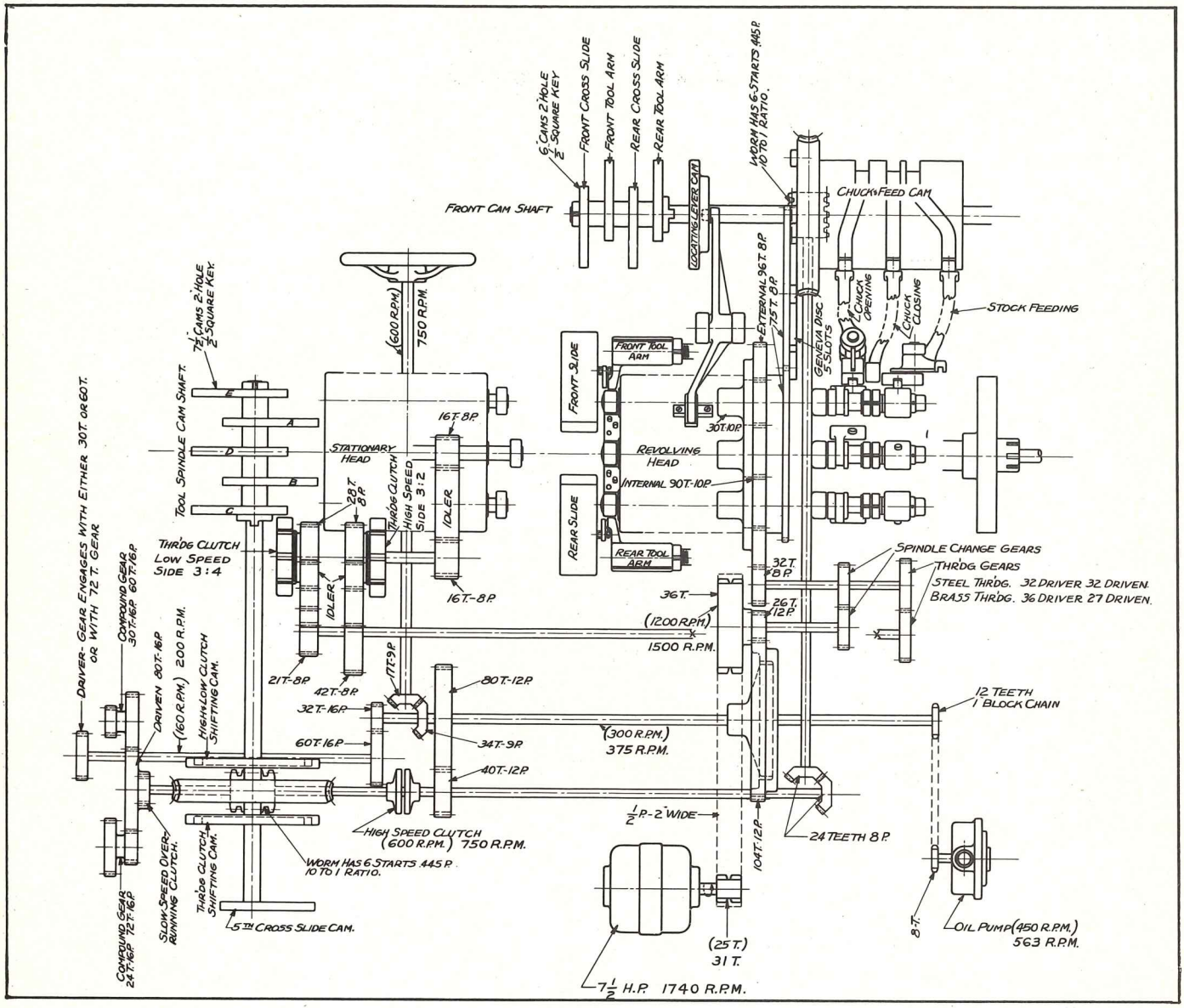
Since all five work spindles rotate at the same speed, and one-half of each camshaft revolution is at a fixed rate, the machine's cycle time for any given job will vary according to the interval required for the remaining 50 hundredths of camshaft rotation during which actual machining occurs.

In order to calculate machining time, it is necessary to determine how many "working revolutions" will be needed for the longest cut to be taken with one tool.

The correlation between feed, speed and distance, as they affect "working revs" is illustrated in Figure 7 where a "tool" *(arrow)* traverses a specified distance as the "thread" is rotated. In the top view the feed rate is such that 10 revolutions move the tool from point a to point b. Doubling feed rate, as in the bottom sketch, halves the number of revs required to travel the same distance, or, conversely, doubles travel for 10-rev rotation.
Putting this into formula:

$$\frac{\text{Distance}}{\text{Feed Rate}} = \text{Revs Required}$$

Figure 8 demonstrates how this could work out on a machine such as the Davenport where simultaneous cuts are taken with independently cammed tools. In the situation shown, feed rates have been adjusted to require 100 revs each for six different lengths of stroke. As will be discussed in detail later in the series, in an ideally balanced setup,



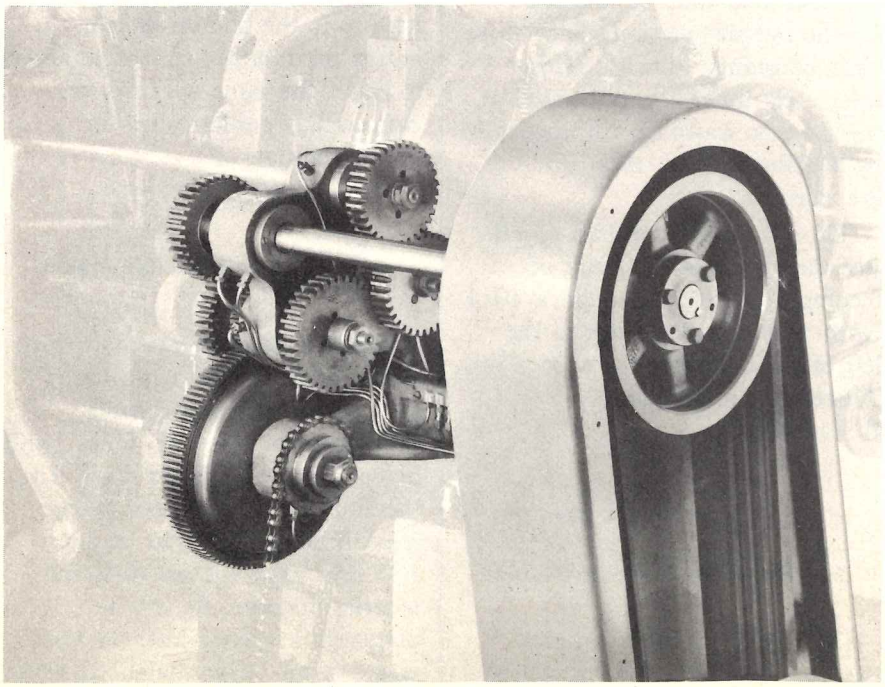


FIGURE 6

MACHINES Serial No. 2333 and higher, are belt driven, as shown at left, rather than being chain driven.

no tool must "wait" for another. For the moment, observe that while in Figure 8 the cuts vary in length, all end at cam space 50 where the machine shifts into "high" for retraction of tools, carrier index, stock feeding, etc. An exception to this rule will be covered in the next installment, but for now, accept as a working premise that *all tools must complete their cuts by the time all cams reach the point where rapid traverse begins.*

Returning to the thread form sketch, Figure 7, it will be evident that *time* required for a specified number of working revs is a function of speed at which the thread is rotated. Using a ridicuously slow example for purposes of simplicity, assume the thread at top were revolved at two different speeds: 10 r.p.m. and 20 r.p.m.

At 10 r.p.m. the tool will traverse from point "a" to point "b" in one minute; at 20 r.p.m. the same distance would be covered in 30 seconds. Applying the same conditions to the coarser feed in the lower view, distance "ab" would be traveled in 30 seconds at 10 r.p.m., or, distance "ac" in 30 seconds at 20 r.p.m.

From this it will be obvious that screw machine cycle times are shortest when both feed and speed are as high as practical for the material being cut.

'Longest Operation'

If all cuts end at a predetermined cam space, as shown in Figure 8, it follows that all others "overlap" the time required for the longest operation. Therefore, if the time for the longest cut is calculated and added to the machine's idle constant, the "cycle time" for a given workpiece is known.

This rule applies for all multi-spindle automatics. However, Davenports differ from most of the rest in having capability to alter both feed and stroke for five endworking, and four cross working tools. This will not be the case on makes of multiples where several

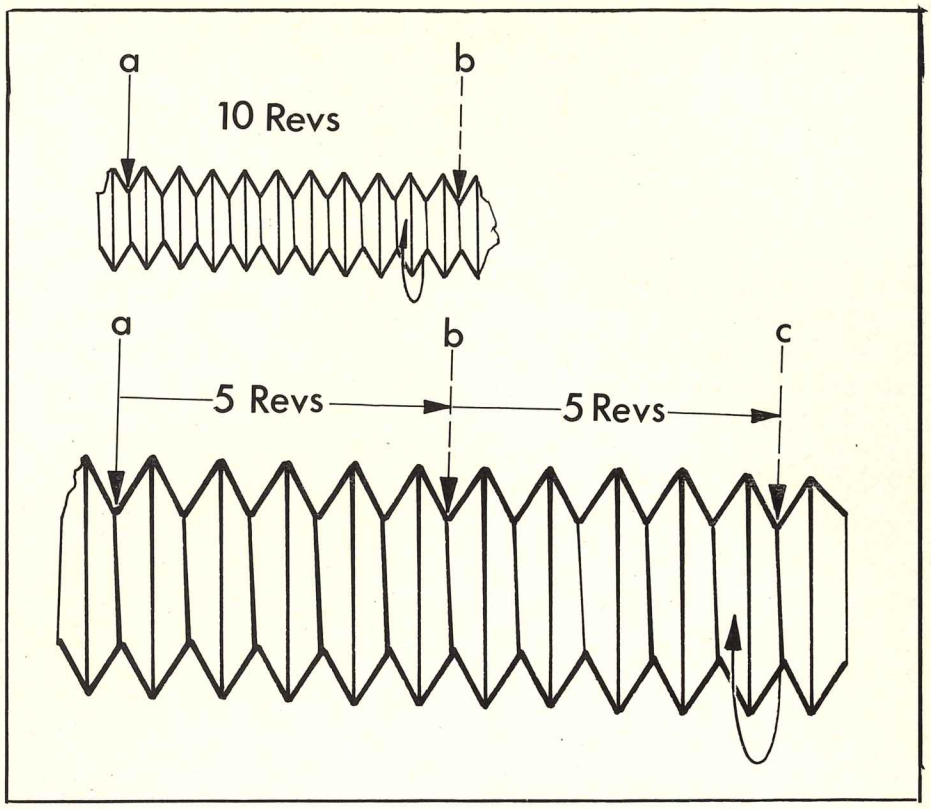
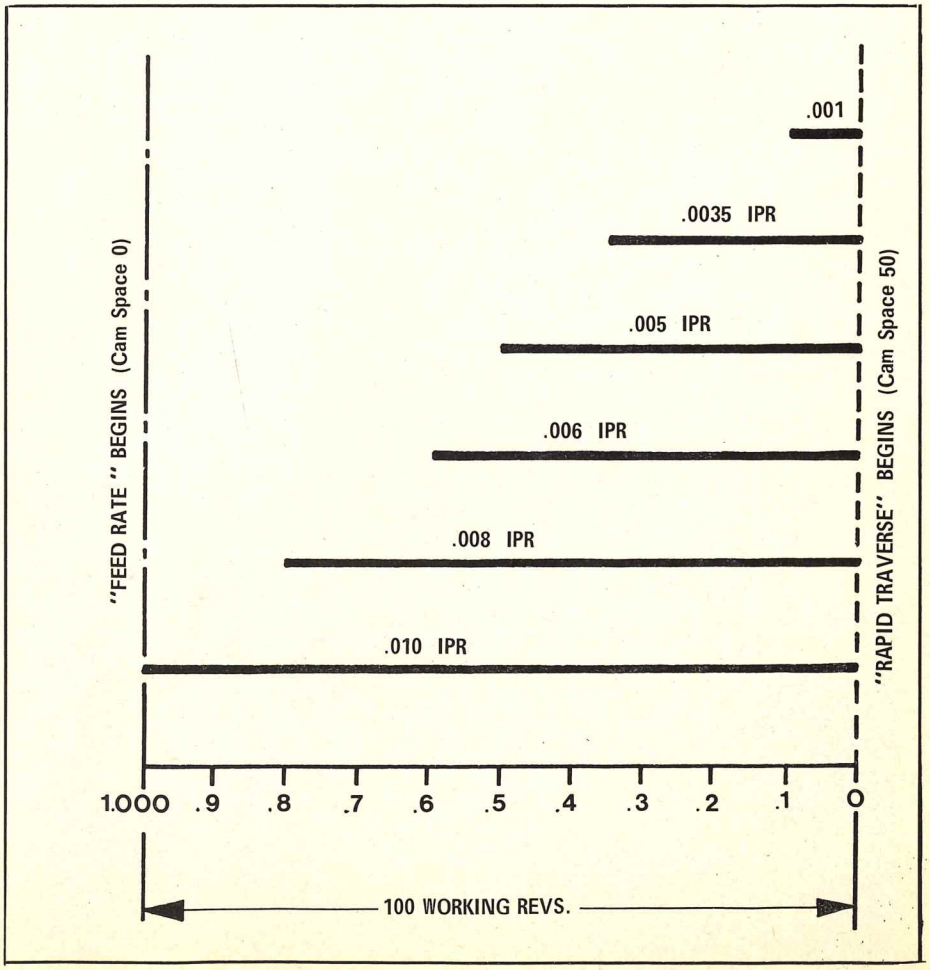


FIGURE 7

FIGURE 8



tools, mounted on a common slide, are actuated by a single cam. In that case, feed and stroke would be identical for all tools on the slide, and those requiring less than maximum stroke would simply "cut air" while waiting to make contact with the work material. Such a condition dictates, also, that the feed rate for all tools be no heavier than that allowable for the one taking the lightest, or most precise cut on the workpiece. Screw machine feed is always stated in inches per revolution, often abbreviated "i.p.r."

In most instances an endworking operation will require the most revs. However, *all* cuts, including those from the cross slides, should be checked using the formula:

$$\frac{\text{Tool Stroke (in.)}}{\text{Feed (i.p.r.)}} = \text{Working Revs}$$

Calculating Revs

For illustration, assume a 1/4-inch diameter hole is to be drilled 7/16-inch deep in B-1113 steel, a common screw machine work material. Referring to a table of recommended feeds and speeds *(such as Republic Steel's Union Drawn Handbook, "Machining Data For Cold Finished Bars")* it will be found a .250-inch drill can be fed at .0054 i.p.r. in B-1113. Dividing work stroke by feed:

$$\frac{.4375}{.0054} = 81 + \text{revs}$$

Call it 82.

Assuming drilling to be the longest operation in the setup, we go back to the handbook and find B-1113 steel should be cut at about 200 surface feet per minute, using high speed steel tooling. Surface feet per minute *(s.f.m.)* is the amount of material, in feet, which moves past a tool in one minute and is, therefore dependent on the diameter of the work material and speed of rotation.

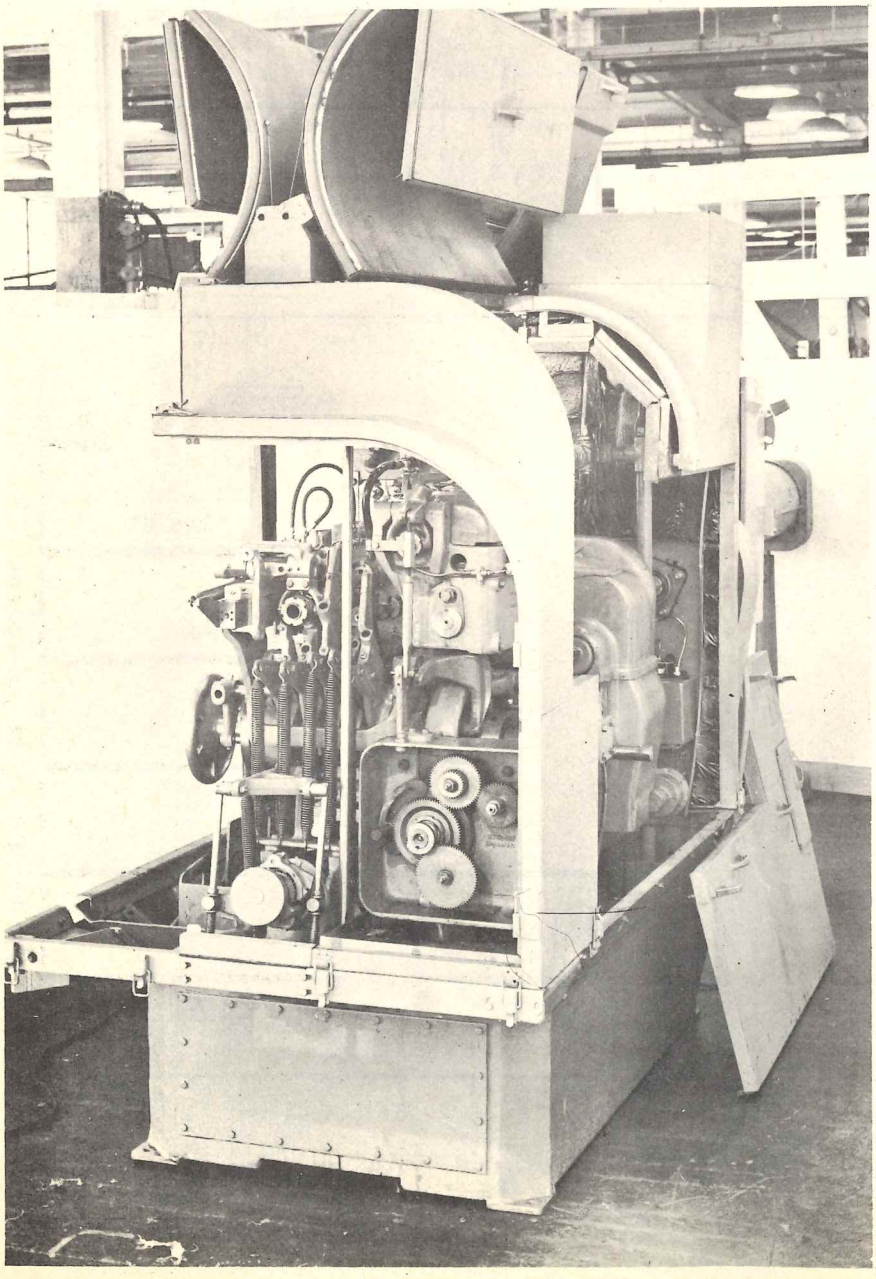
The same handbook which gives recommended feeds and speeds is sure to have a table for converting r.p.m. to s.f.m. If, for some reason, surface footage must be computed, it can be found by multiplying bar circumference in feet by spindle r.p.m.

For present purposes, however, assume an r.p.m./s.f.m. table is at hand, and on it we find the 1/2-inch diameter bar stock chosen for the job will have the desired 200 s.f.m. if spindles are run at 1528 r.p.m. The machine would then be fitted with nearest available spindle change gears. In the case of the Model B Davenport, a gear chart in the operator's manual shows a 32-32 driver/driven combination yields 1500 r.p.m., amounting to 196 s.f.m. on half-inch bar stock. For further computation it will be assumed this is the speed selected.

Earlier it was determined the longest operation *(drilling)* required 82 revs. Knowing spindle speed, calculate machining time by dividing r.p.m. into working revs:

$$\frac{82}{1500} = .054 \text{ min.}$$

$$.054 \times 60 = 3.24 \text{ seconds.}$$



SPEED CHANGE GEARS and tool spindle quadrants are visible through opened section of Davenport's recently announced acoustic machine enclosure.

Machining time plus idle constant yields time per piece: 3.24+.4=3.64 seconds per "cycle."

To find hourly output, divide cycle time in seconds into 3600 *(one hour in seconds)*:

$$\frac{3600}{3.64} = 989 \text{ parts per hour (p.p.h.)}$$

Gross vs. Net

In screw machine terminology the 989 p.p.h. figure would be the "gross" production rate at which parts could be made if the machine ran one hour without interruption. In practice this is seldom the case. At regular intervals an automatic must be shut down for restocking, tool inspection or adjustment, and other reasons. Therefore, gross production is a theoretical base from which to estimate cost and evaluate actual or "net" hourly output.

Little would be gained by choosing spindle speeds and feed rates which yielded very short cycle time but required such frequent shutdowns that net productivity suffered. The more or less arbitrary rule of thumb in the industry is that cycle times should be set at rates which net 80 percent of gross as an eight-hour average.

The next installment will deal with exceptions to this, and other rules. ■

DAVENPORT PRINCIPLES

Basic Instruction: PART 3

EVERY STATEMENT made in the first two installments of this series is technically accurate. However, to avoid confusion during discussion of fundamentals, some matters were deliberately left unmentioned. Here we shall cover exceptions to general rules.

In the previous chapter, referenced to Figure 8, it was said all tools must complete their cuts by the time all cams reach the point where rapid traverse begins. True enough, so long as rapid traverse begins at the normal 50 hundredths line. One exception on a Davenport would be when the machine is geared for .8-second cycle time in which case it runs at what amounts to rapid traverse rate continually. This totally-in-high concept, as will be seen a little later, is safe and practical under certain conditions.

While all cams must reach high point by the 50 hundredth mark, this does not preclude one or more completing their cuts prior to that time. To appreciate what could occur if this were not possible, consider the situation at Davenport Position E *(Figure 9)* where an endworking face-and-chamfer operation is combined with cutting off from the cross slide.

If both tools topped their cams at the same hundredth line, the part would still be in process of being faced as it dropped from the bar. To avoid situations like this *(which could also occur during reaming, tapping or internal recessing)* Davenport provides "early return" cams of the sort labeled "Pointing" in center row, Figure 10. On both of these, the feed rate rise begins at cam space 0, but ends at 23 hundredths rather than at space 50. The remaining 27 hundredths are used to retract an endworking tool while a cross slide completes its forward motion. The High Pointing cam, being 2½ inches larger in diameter, is generally used for short workpieces while the Low Pointing cam is intended for longer parts. Both are Tool Spindle Cams, meaning they are solely for endworking operations. Form and Cutoff cams *(top left, Figure 10)* can be used for end or crosswise work; Turn and Drill cams *(top center)* cannot.

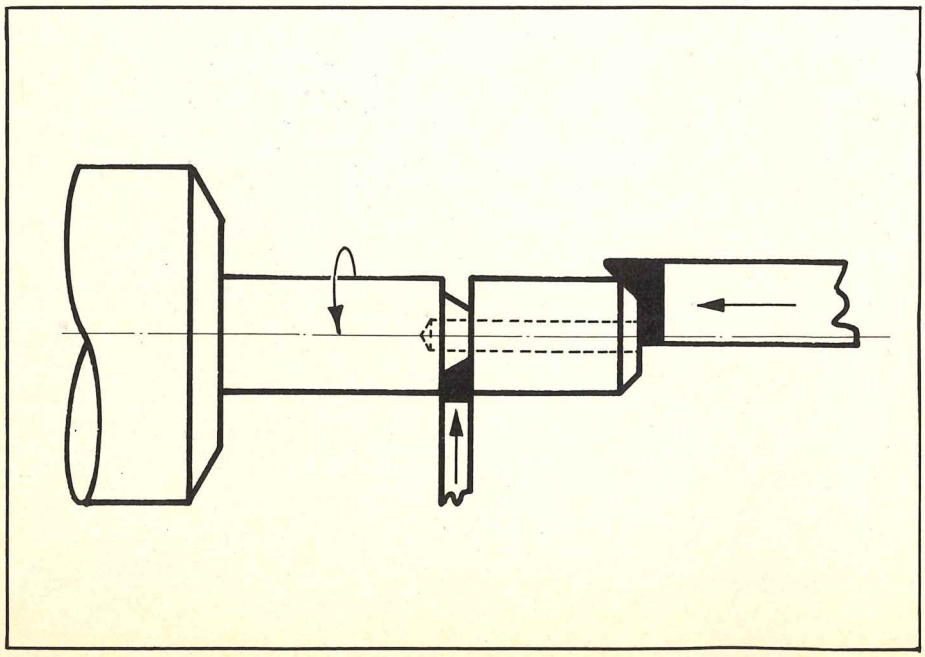
The Support cam *(top right)* is designed to move a bushing or steady rest into position on the workpiece and then dwell while other operations take place. A somewhat similar cam might move a recessing tool into a part so a Recess Pusher cam *(center right)* on a cross slide could actuate the tool sidewise to produce an "undercut" in a hole.

Threading cams will be discussed later, but before leaving the subject it should be mentioned again that the quadrant linkage system for Davenport automatics permits tool throws to be 20 percent more, or less, than actual cam rise. Frequently this avoids need for changing cams when setting up a new job. However, a variety of cams must be on hand in order to choose ones which are within adjustment range for whatever tool strokes are required.

In addition to standard cams, there may be need for specials such as the deep drilling cam *(bottom right)* which includes two chip-clearing "pullouts."

Restating the rules: All cams must finish their cuts by the 50 hundredth line on a Davenport even if the machine is running continually in rapid traverse, but when required, cams may top their rise and return early.

FIGURE 9



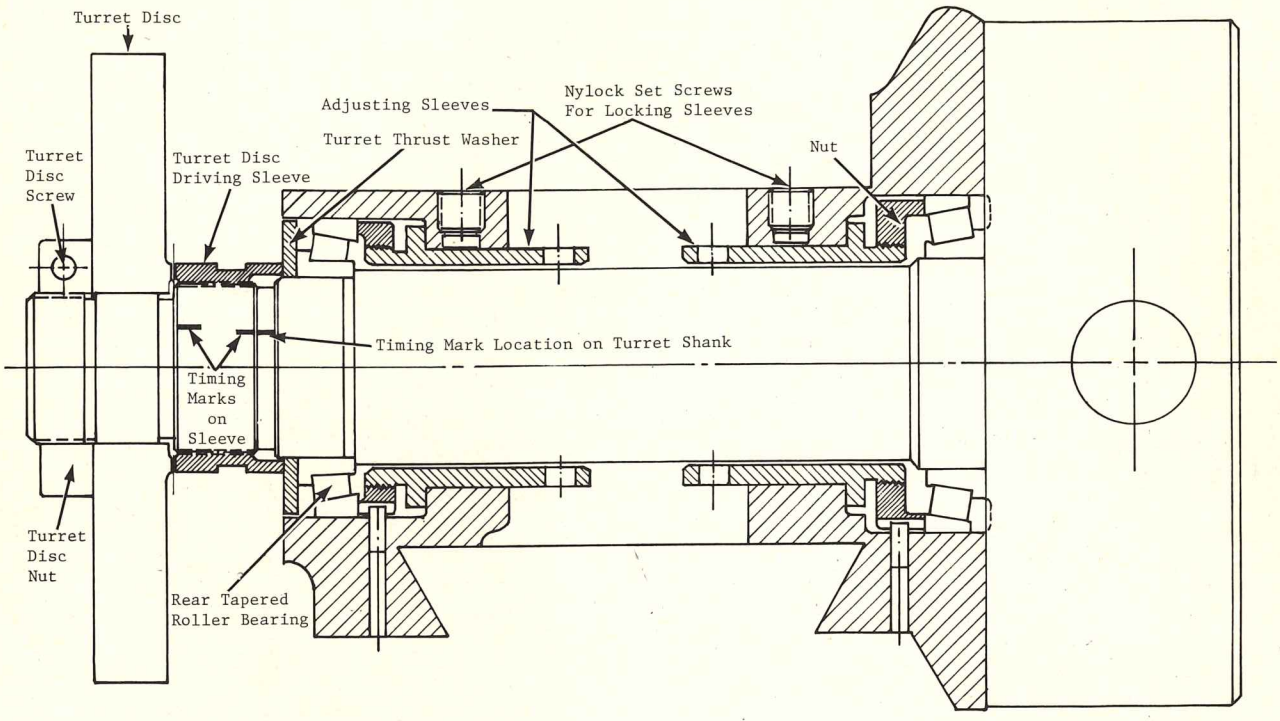


Fig. 2C Timken Bearing Turret Assembly

The foregoing material is taken from the 'Brown & Sharpe Automatic Screw Machine Troubleshooting Guide' available through B&S representatives for $20. Price includes a registration card entitling the owner to additional looseleaf pages soon to be issued covering No. 00's Serial 542-00-3300 and higher, and No. 2's Serial 542-2-3100 and above.

B&S urges any who have already purchased the Guide to make sure their registration card has been returned. Suggestions for subjects to be covered in future update sheets and any comments on existing material will be welcomed by John E. Crabb, Service Manager, Brown & Sharpe Manufacturing Co., Precision Park, North Kingstown, R. I. 02852. ■

Thread Rolling Attachment

A 24-page instruction manual on its 140 SA thread roll attachment is offered by Winter Machine Works. Included is a complete listing of models, together with mounting position, of Acme-Gridley, New Britain, Warner & Swasey, and Wickman machines on which the attachment may be used. Thread rolling and knurling capacities are given.

Besides detailed installation and setup data, the brochure includes a three-page problem checklist and a complete attachment parts list.

For data circle **249** on Readers' Card.

Hydraulic Tools

Hydraulic tools for a variety of industrial applications, including production, assembly, fabrication, maintenance, testing and quality control, are highlighted in Enerpac's new catalog, E-307.

Included are portable split-flow hydraulic power pumps, a new line of all directional *Saf-T-Lite* aluminum jacks, a full line of hydraulic cylinders, hydraulic pumps, presses, load cells, maintenance and pulling equipment, valves, and complete hydraulic systems.

For data circle **244** on Readers' Card.

Marking Equipment

Imperial Stamp & Engraving Co. has published a new 24-page catalog featuring a wide range of marking equipment and machines.

The catalog contains complete specifications and dimensions on hand stamps; hand, press and radial type holders numbering heads; dies; pneumatic and hydraulic presses; roll marking machines; etc.

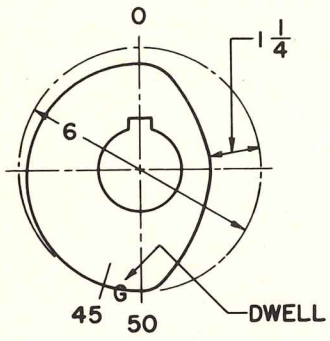
Each item is fully illustrated, and complete with specification data in the form of engineering drawings and charts.

For data circle **183** on Readers' Card.

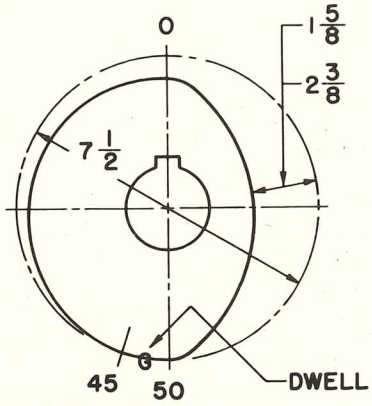
MODEL B MACHINE AND MODEL B OVERSIZE MACHINE
OUTLINE OF STANDARD CAMS

HOLE IN ALL CAMS 2" DIA.
WORKING PORTION 0 TO 50

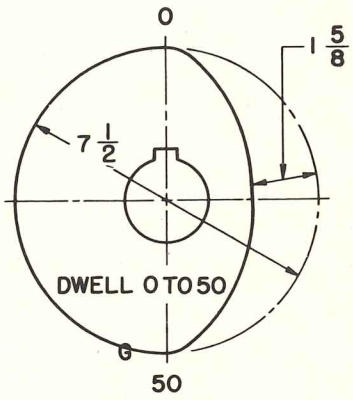
KEYWAY $\frac{1}{2}$" WIDE X $\frac{17}{64}$" DEEP
IDLE PORTION 50 TO 0



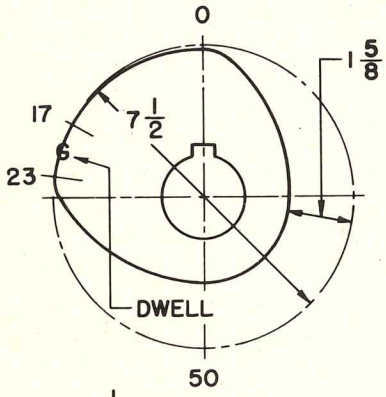
FORM & CUT OFF



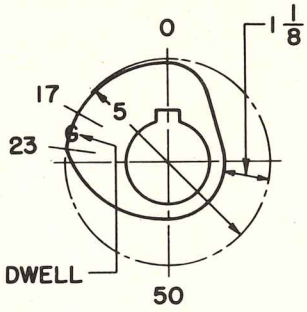
TURN & DRILL



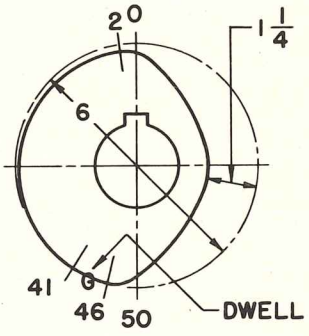
SUPPORT



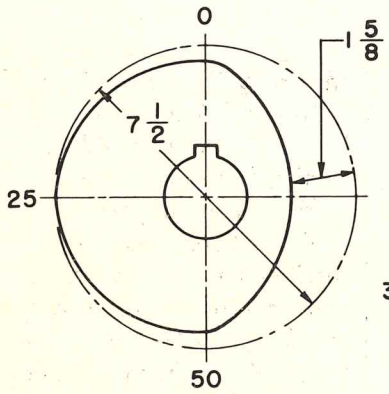
$\frac{1}{32}$ HIGH POINTING



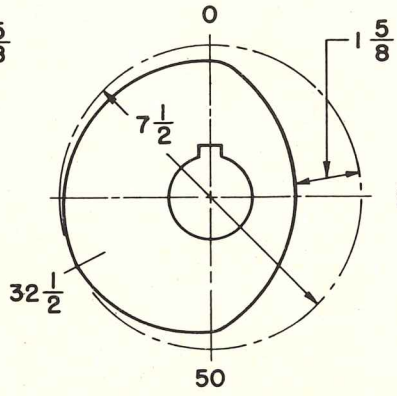
$\frac{1}{32}$ LOW POINTING



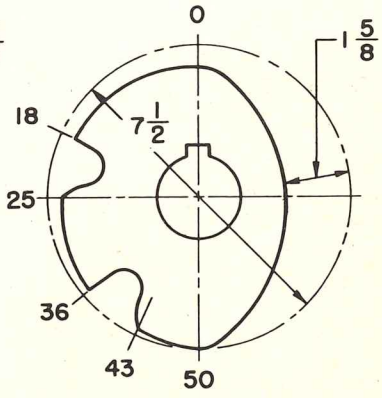
RECESS PUSHER



BRASS THREADING



STEEL THREADING



SPECIAL DRILL

FIGURE 10

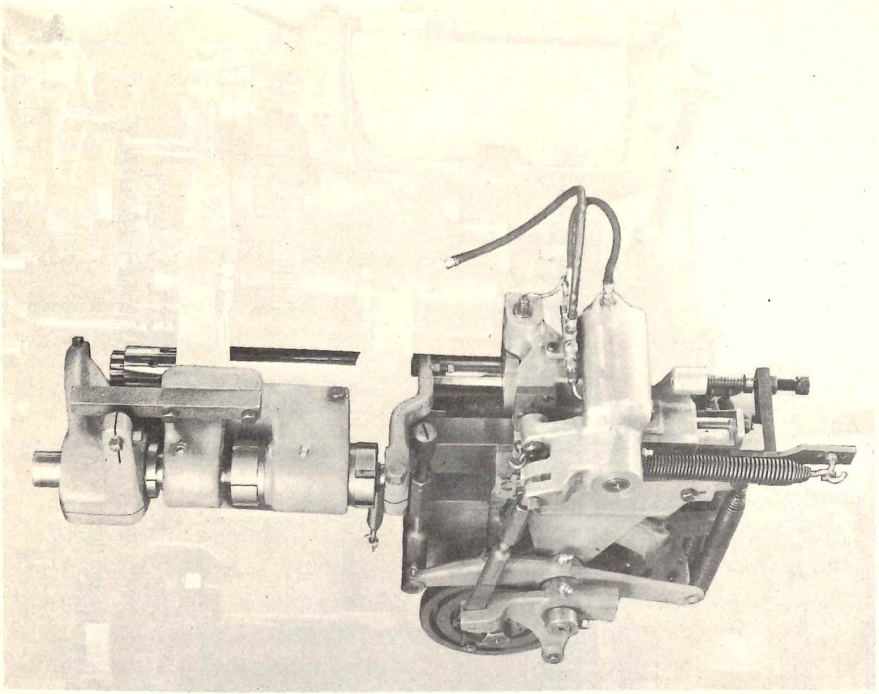


FIGURE 11

Surface Footage

Previous installments stated that surface feet per minute *(s.f.m.)* is bar circumference in feet multiplied by spindle r.p.m. This, also, is true, provided the tool is stationary, as would be the case when forming, cutting off, or performing endwise operations from a "dead" tool spindle. An exception arises, however, if both the tool and the workpiece are rotating. If both are revolving in the same direction, s.f.m. must be calculated from the *difference* in r.p.m.'s if tool and work rotate oppositely, surface speed is computed from the *sum* of r.p.m.'s. If the work is stationary, as will sometimes be the case on Davenports arranged for "spindle stopping," then s.f.m. is calculated on the basis of *tool* r.p.m. If work and tool run at the same speed in the same direction, s.f.m. is zero.

A few examples may be helpful as we consider the implications of this important factor in screw machine capability.

Differential Speed Principle

Visualize two cars moving in the same direction on an open stretch of divided highway. So long as both run at exactly the same speed their motion, relative to each other, is zero. By speeding up or slowing down, one can gain or lose on the other.

In more exotic situations the same principle has been used to gently "dock" space craft traveling more than 25,000 m.p.h., and to let one jet aircraft serve as a filling station for another while in flight. For purposes of this article the important point is that by using the concept of speed differential it is possible to slow down or speed up a cutting operation *without changing spindle r.p.m.*

Taking one of the simplest situations first, assume that instead of facing and chamfering the workpiece in Figure 9 there was need to support and drive it from the outboard end during the cutting off operation. Davenport's approach to this rather commonplace requirement is to mount a Stationary Head Burring Attachment in cutoff Position E. This device *(Figure 11)*, synchronized to rotate exactly at spindle speed, advances and then dwells while a chuck grips the piece in much the same manner as it would be held by a collet on the headstock side.

This procedure eliminates the burr which is almost sure to exist if unsupported workpieces fall of their own weight before the cutoff tool completes its forward travel. Since the Burring Spindle is driven from the spindle power train *(see Figure 6, Part 2)* it remains synchronized and can, therefore, "pick up" and support hexagonal, square, or other non-round bar shapes.

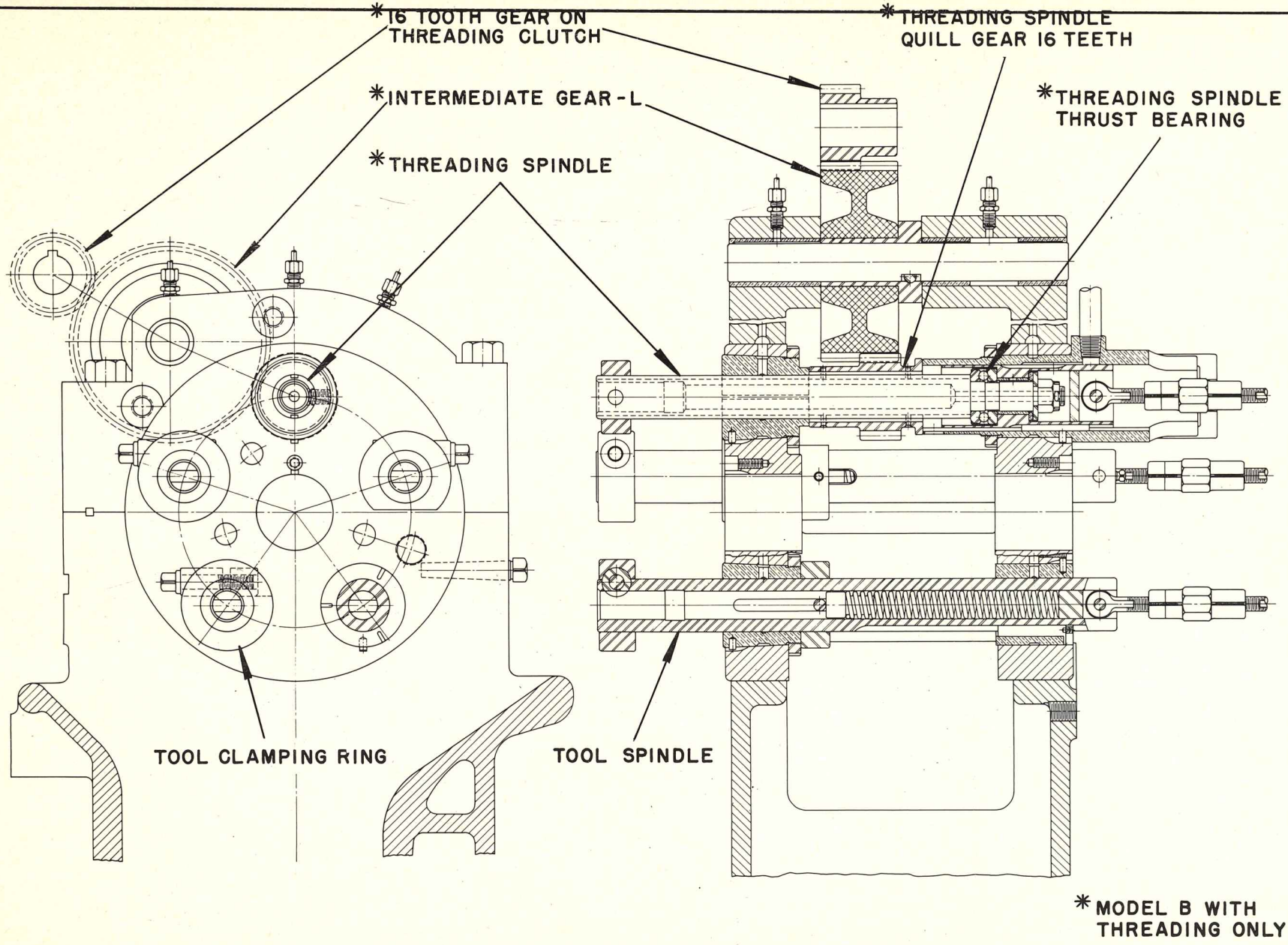
Normally the workpiece is dropped as the burring spindle retracts. However, the part can be withdrawn just enough to allow a counter-sinking or counterboring tool to be swung into line behind it, then cammed forward against left-hand tooling to accomplish relatively light work on the cutoff end.

Threading Spindle

As mentioned earlier, Station D is usually reserved for cutting threads. Threading in this topmost position not only follows standard screw machine practice of protecting taps from falling chips, but also provides three prior working positions for such preparatory operations as drilling, turning or forming. Referring again to the power train diagram, Figure 6, it will be seen the Threading Attachment at Station D is driven from the same source as the Burring Attachment.

A basic difference exists between the two, however. The Burring Spindle, synchronized with the spindle, is analogous to two cars traveling down the road at exactly the same speed. Motion of one, relative to the other, is zero.

The Threading Attachment *(Figure 12)* is designed to rotate slower than the spindle, but can be run faster by shifting a clutch from the low to the high side. Speed differential between workpiece and Threading Spindle is variable through change gears, and if required can be set for synchronized rotation *(in cases where the spindle is used for supporting)* or can run in reverse direction to "speed up" a very small diameter tool.



SECTION THRU THREADING & TOOL SPINDLE

FIGURE 12

In the case of opposite rotation, tool and work r.p.m.'s are *added* and multiplied by machined diameter in feet to arrive at s.f.m. for a given operation.

Example:

Machine spindle speed 1500 r.p.m.

Threading Spindle speed 1250 (opposite direction)

Operation: drill ¼-inch hole.

$$1500 + 1250 \times \frac{.25 \times pi}{12} = 180 \text{ s.f.m.}$$

Used in this manner, the Davenport Threading Spindle becomes a means of accelerating a tool which would otherwise have too low surface footage for proper function. This is frequently the case where small holes are drilled in rather large bar stock that must be rotated at a speed consistent with cuts taken on major bar diameter.

To illustrate, if half-inch material were used in the above example, spindle speed of 1500 r.p.m. would yield 196 s.f.m., but only about 100 s.f.m. on the periphery of a ¼-inch drill. Rotating the drill counter direction evens up conditions by giving the drill approximately the same s.f.m. as tools working on the outside of the bar. Additionally, it has the effect of reducing by more than 40 percent the feed per rev, compared to what would result if the drill were stationary. However, for purposes of calculating the longest operation, as covered in Part 2 of this series, drill rotation is ignored and stroke is divided by cammed feed rate in computing required working revs.

Threading On and Off

While some tools, such as small diameter drills, require an increase in surface footage, others, such as taps and die heads, need to run at lower s.f.m. On Davenport automatics, as on most others, this is arranged by rotating the thread cutting tool in the same direction as the work, but at a slower speed for "threading on," then shifting to a faster-than-spindle rate for "threading off."

Steel Threading Method

The sequence just described is Davenport's recommendation for cutting right-hand threads with a tap or non-opening die head. Left-hand threads are produced similarly except the threading spindle runs faster than the work for tapping in, then slows down for tapping out. In either instance, required revs are caluculated on the basis of relative speed.

The Davenport Instruction Book, Edition Six, covers these calculations in detail. A simple example will illustrate what is involved.

One standard gear setting revolves the threading spindle at ¾ the speed of the work spindle while threading on, and 1½ times work spindle speed for threading off. Since the work spindle is the faster "car" during threading on, it gains on the tap at a rate of one revolution in four. During threading off, the tap is half again faster, and gains on the work at a rate of one rev in every two. As a result, six spindle revolutions are required to cut one thread on and off.

Alternatives

In cases where the Steel Threading Method makes this operation the longest in the cycle, two rev-reducing options are available:

If O.D. threads are cut with a self-opening die head, chasers can be run on at steel threading speed, then popped open for rapid retraction to save threading-off revs. An alternative, "Brass Threading Method" in Davenport terminology, calls for stopping one side of the clutch *(depending on whether right or left-hand threads are being cut)* so the threading spindle is non-rotating during threading on. The clutch is then shifted to the opposite side for differential speed threading off.

This reduces revs to a greater extent than any other method, but requires threads be cut at s.f.m. based solely on spindle r.p.m. *(2500 r.p.m. max.)*. Therefore a decision to use Brass Threading should never be made arbitrarily.

The next installment will review machine construction and attachments as a preliminary to study of actual layouts. ■

DAVENPORT PRINCIPLES

Basic Instruction: PART 4

As mentioned earlier, all Davenports, new or old, are essentially similar in design. Differences, when evident, will be mainly in the area of internal machine improvements, or attachments.

Since the two subjects are interlocked, this installment will begin with the specification chart *(Table 1)* of a Davenport Model B equipped for differential-speed threading.

As a further review of fundamentals, Figure 13 gives a cross-sectional view of the machine as seen from the operating side.

Endworking positions on a Davenport are called "tool spindles" because, when required, tooling can be rotated in positions other than D and E.

For example, a Rotary Slotting attachment *(Figure 14)* normally mounts in Position C to allow endwise milling cuts to be taken without stopping the work spindle. As in the case of support operations *(covered in Part 3)* this is accomplished by rotating a cutter-carrying head in the same direction, and at the same speed, as the work. One milling cutter is normally used for producing an on-center slot of screw driver type two cutters, spaced apart can saw opposed wrench flats on the O.D. of a part.

While the Rotary Slotting Attachment is important in itself, it takes on added capability when combined with a Revinloc device developed by Davenport in 1949. In effect, the Revinloc allows one or more rotating milling cutters to be withdrawn from a first cut, indexed a specified number of degrees, and returned to the work repeatedly without stopping either the tool or the work spindles. By so doing it is possible to produce a hexagonal shape in three straddle milling passes, or to complete work such as the slotting of a castellated nut.

Although the primary intent of these attachments is to avoid stopping work spindles, they can be used as non-rotated endworking milling heads if, for some reason, bar stock does not revolve for a portion of the machining cycle. This in itself requires use of a Spindle Stopping Attachment which uncouples power upstream from the spindle carrier ring gear.

One reason for spindle stopping is to allow radial holes to be produced with attachments such as the Fourth Position Cross Drilling Attachment, Figure 15. By using a similar unit in Third Position (C) and locking work spindles to prevent their rolling out

SPECIFICATIONS AND EQUIPMENT
FOR MODEL B DAVENPORT (WITH THREADING)
FIVE-SPINDLE AUTOMATIC SCREW MACHINE

CAPACITY	Regular capacity of feed tubes — 9/16″ round, ½″ hexagon, ⅜″ square. Special feed tubes with feed fingers soldered in can be furnished to take stock up to ⅝″ round, 9/16″ hexagon, and 7/16″ square. Longest length fed — 3″ Special blocks can be furnished to feed 4¼″ long Longest length turned — 2½″ Number of changes of spindle speeds — 11 Range of spindle speeds — 750 r.p.m. to 3000 r.p.m. Number of changes of feed gears — 29 Range of feed gears — .8 to 15.8 seconds
SPEEDS	Speed of driving shaft — 1500 r.p.m. Handwheel shaft — 750 r.p.m. Indexing head, feeding stock, etc. — 2/5 second constant Steel threading method — threading spindle revolves in same direction as work spindle, at ratio of 3 to 4 while threading tool is running on to work and at 3 to 2 while running off (right hand threads) Brass threading method — threading spindle is stopped when tool is running on, but runs twice the speed of the work spindle running off (right hand threads) First feed change gear shaft — 200 r.p.m.
PRINCIPAL DIMENSIONS	Diameter of circular form tools — 2″ Diameter of hole in tool spindle — ¾″ Outside diameter of tool spindle — 1⅜″ Least distance between chuck and tool spindle — 2⅛″ Greatest distance between chuck and tool spindle — 4 13/16″ Diameter of standard turning cams — 7½″ Diameter of standard form & cut-off cams — 6″ Thickness of cams — ⅜″
SIZES & WEIGHTS	Floor space — 36″ × 176″ Distance from top spindle to floor — 46 3/16″ Net weight machine — 3843 lbs. (domestic or foreign)

TABLE 1

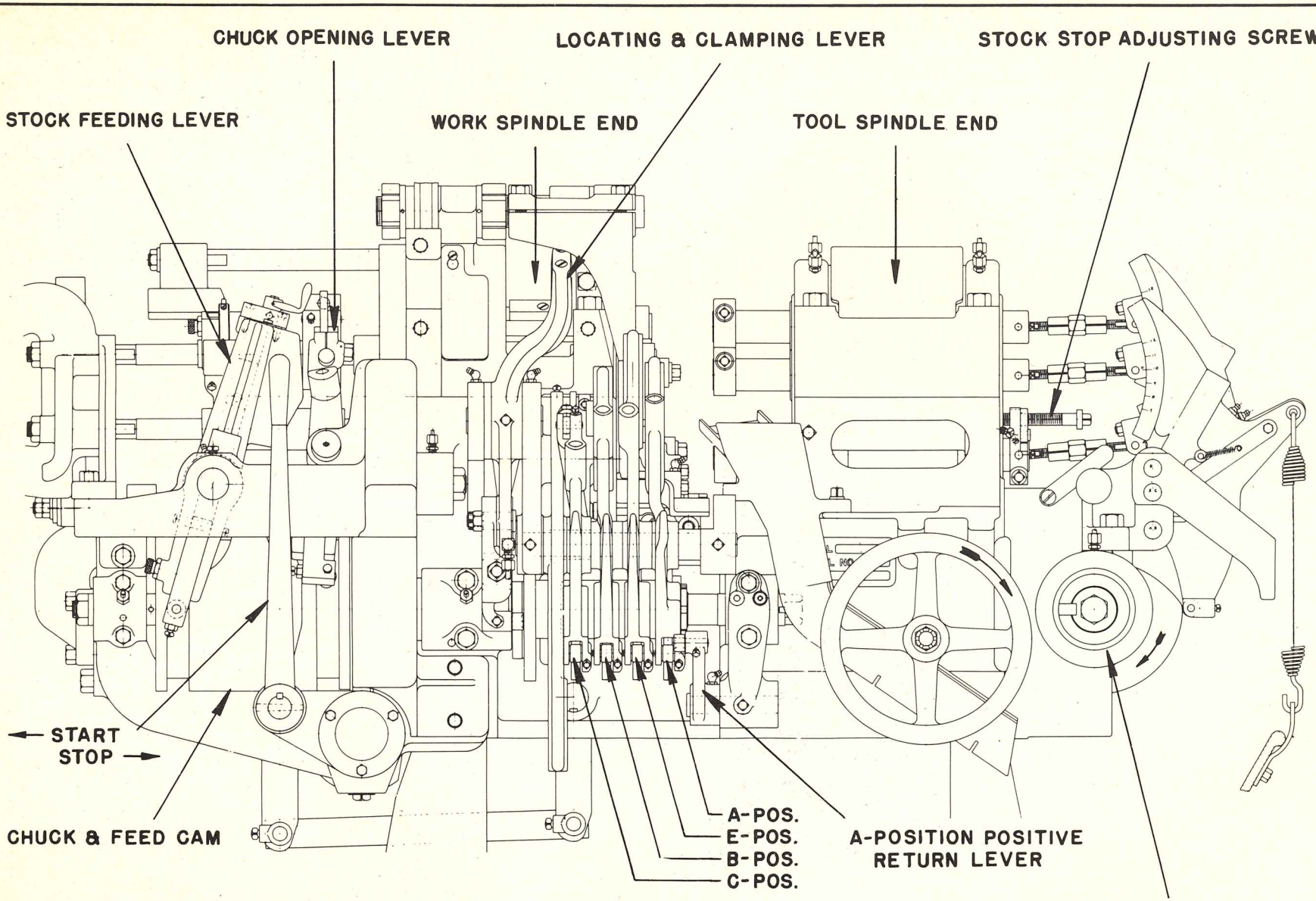
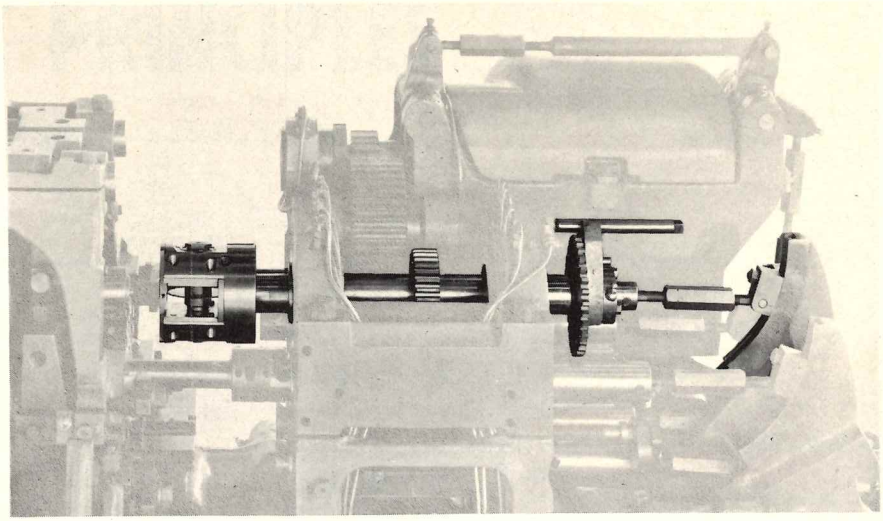

CHUCK OPENING LEVER
LOCATING & CLAMPING LEVER
STOCK STOP ADJUSTING SCREW
STOCK FEEDING LEVER
WORK SPINDLE END
TOOL SPINDLE END
START
STOP
CHUCK & FEED CAM
A-POS.
E-POS.
B-POS.
C-POS.
A-POSITION POSITIVE RETURN LEVER
TOOL SPINDLE CAM SHAFT
A-POS. FRONT CROSS SLIDE
B-POS. REAR CROSS SLIDE
C-POS. REAR TOOL ARM
E-POS. FRONT TOOL ARM
FRONT VIEW

FIGURE 13

FIGURE 14 →



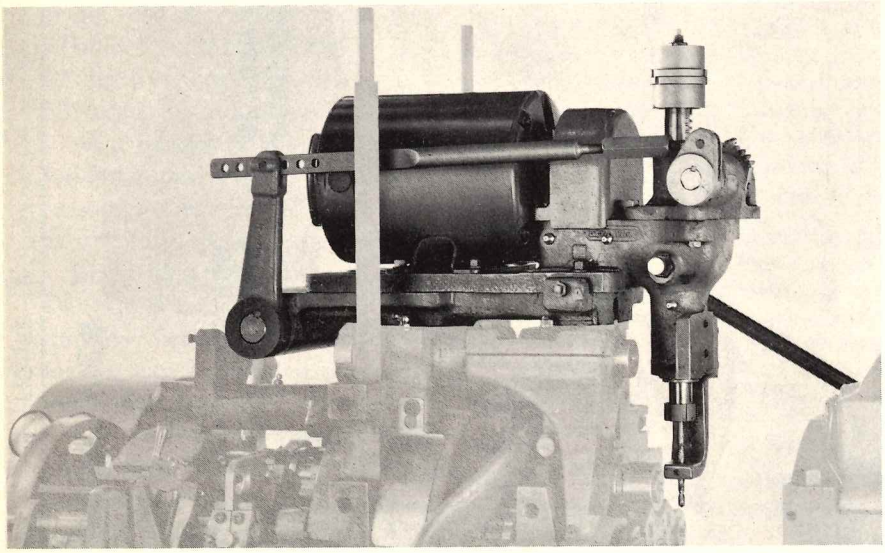


FIGURE 15 ←

of location during indexing of the carrier, two separate cross holes can be drilled, or one can be drilled in Third Position and then reamed *(or tapped)* in fourth.

With work spindles stopped, a Keyway Milling Attachment *(Figure 16)* can mill a straight groove, or, by means of a formed guide, can cut configurations such as the slot for a bayonet lock.

While devices mentioned here are typical, Davenport Machine Co.'s latest catalog lists and describes more than a half hundred attachments or capacity-stretching arrangements for its basic five-spindle automatic. Some are special; most are standardly applicable for operations within the range of the machine. Of them all, perhaps the one which has greatest effect on capability is Spindle Stopping.

The reason is: By rotating *tool spindles* it is possible to drill, ream, face or hollow mill while bars are stopped for work done with cross slide attachments. Conversely, cross working attachments requiring stationary bar conditions cannot be used if work spindles must run continuously. In either instance it should be kept in mind that attachment usage whether on tool spindle or cross slide, usually will require specially cut actuating cams.

'Secondary' Operations

The previous installment described a Stationary Head Burring Attachment, *(Figure 11)* on which an arm at the headstock end drops a left-hand countersink behind the workpiece after cutoff at Position E to allow the back end of a through hole to be chamfered.

A device of similar nature grasps a part just prior to cutoff, then swings it upward to a position where it is pressed rearward against a motor-driven milling cutter. As can be seen, the Screw Slotting Attachment, *(Figure 17)* mounts on the front of the machine and is actuated by a cam on the left end of the tool spindle cam carrier.

Larger attachments such as these normally are left in place and considered part of the standard capability of the machine. If not needed for a particular job, they are deactivated by removing tools and cams and moving members as far as possible out of the way.

Smaller attachments, or ones

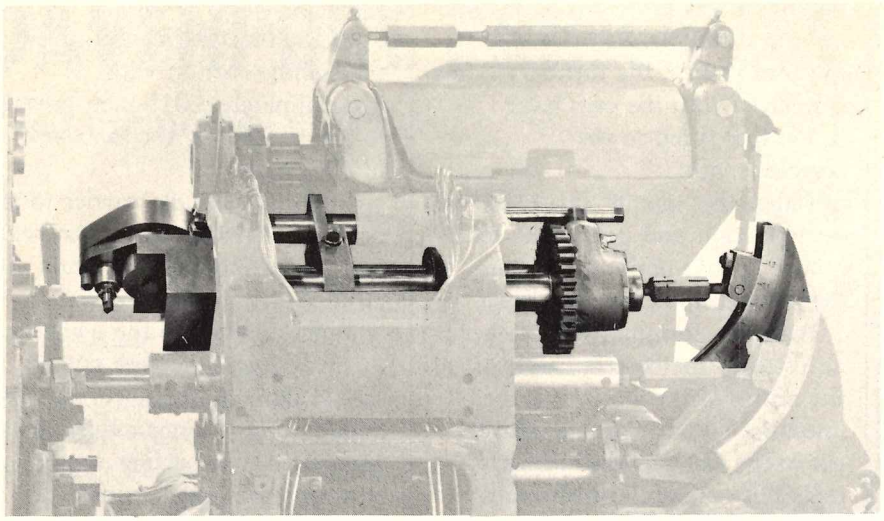


FIGURE 16

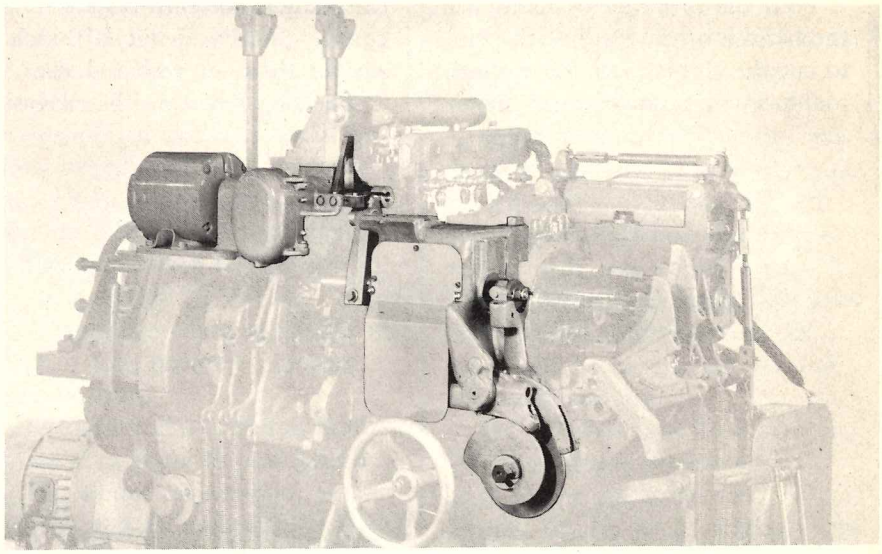


FIGURE 17

which preclude normal usage of an end or crossworking position are generally stored until needed, then mounted on whichever machine requires them. Attachment cams usable for a specific workpiece are best kept with special tooling for that job, rather than in the department's cam "library."

Tooling Up

The next three installments will use actual layouts to explain why the operations were sequenced in a given manner. Before closing this chapter, here are the steps required for a setup as given in Davenport's Instruction Book, Sixth Edition:

When tooling up a new job, if the machine has been running on other work remove all tools, take out the feed tubes and put in the new feed fingers; take out the chuck from the spindle which is in the cutting off position and wash out the spindle with a piece of waste soaked with gasoline. Put in the new chuck and after it has been tightened up by hand, the wrench should be struck a sharp blow with a hammer to make sure it will be tight.

Put in the feed tube and index the head, bringing another spindle to the cutting off position; put in another chuck and feed tube, repeating the operation until all five feed tubes and chucks are in place.

Insert five bars of stock into the machine and adjust all chucks. Adjust the amount the stock will be fed by the crank on top of the feed slide, usually allowing 1/8-inch longer than the piece to be made.

Take out the cam carriers and put in the new set on which the cams for the new job have already been mounted. Locate the block on the cam levers to get the required amount of movement for the tools.

Put on the spindle change gears and feed gear. Adjust the threading equipment for the desired type of threading.

The machine is now ready to put in the tools, which should all be correctly sharpened before starting to set up.

Put in the cutoff tool and adjust approximately 1/16-inch away from the face of the chuck. Sever the end from the bar by operating the cutoff tool by hand.

Open the chuck and feed out stock the length of the piece that is to be made. Close the chuck by

hand and cut a slight groove in the stock.

Withdraw the latch on the top of the chuck opening lever so that the stock will not be fed out in the other spindles as the work spindle head is indexed.

Put the tool holder for the first position in place and index the spindle carrier until the stock comes in line with the stock stop face of the tool holder. Adjust the stock stop screw on the right hand end of the tool spindle head until the face of the holder comes in contact with the stock, and finish indexing the spindle carrier.

Feed the first tool by hand with the hand lever and adjust the tool to cut the correct size. After the tool has been adjusted, turn the handwheel until the roll on the cam lever is at the highest point of the cam. Adjust the turnbuckle link connected with the cam lever so the tool is fed to the correct length.

Index the spindle carrier to the next position and put in the tool holder in that position, adjusting in the same manner as before.

After the forming tool has been adjusted to the correct height to the center of the work, it is then lined up with the groove already cut in the stock by the cutting off tool. When the roll on the cam lever is at the highest point of the cam, adjust the turn-buckle connection so as to cut .010-inch smaller than the required size.

The stop screw on the cross slide is then screwed in until it comes in contact with the stop screw in the spindle carrier, with approximately .0015-inch pressure to assure forming the same size in all spindles.

Index the spindle carrier to the next position and put in the next tool, repeating this operation until all tools are in place.

When tooling up the machine this way, the first piece cut off should be very nearly correct. By making a few minor adjustments as needed, and inspecting a piece of work from each spindle, the machine should be ready to run. Usually these adjustments should be made without over a dozen scrap pieces when setting up the ordinary screw machine job. ■

DAVENPORT PRINCIPLES

Basic Instruction: PART 5

CONCEPTS covered in previous installments will now be used to analyze what Davenport Machine Tool Co. considers to be a simple, but typical, job for its five-spindle Model B bar automatic.

Seldom, except in training material, will the reader find so detailed a description of tools and sequences as is shown on an adjacent page. In most instances the setup man is issued a Part Print *(corresponding to the work sketch at upper left on page shown here)*, a Layout Sheet *(containing data shown in and above the box at right center)* and a Job Tray in which are kept any special tools, fixtures, cams and gages needed for a particular workpiece.

In all probability the plant's engineering department will have drawings of form and sizing tools similar to those shown at bottom, but only in rare situations will these be required out in the shop. Nor will an experienced setup man need the tool position sketches, shown here at left-center; instead, he is able to visualize these relationships from printed descriptions on the Layout Sheet.

Nonetheless, Davenport Machine Tool Co. has provided the diagrams to help explain why the job was planned and timed in the manner shown.

The work material, designated at top-right, is 9/16-inch round steel bar stock. The workpiece, upper left, calls for a tapped hole, and a back-end chamfer. With no more information than this we know:

1. Bar diameter falls within the collet capacity of a standard (75 cycle) Model B Davenport.

2. If the piece is to be completed, the machine must have threading capability, and be equipped with a Stationary Head Burring Attachment with Countersink Arm.

Threading in Station D, and cutting off in Station E, leaves three available positions for all other operations. In keeping with conventional multi-spindle screw machine practice, Davenport chose to re-center the bar end at Station A while counterboring with a short-snubbed drill. This has the effect of reducing by 1/8-inch the through-workpiece-and-past-cutoff distance which must be drilled halfway at Station B, and full depth at C.

To appreciate how efficiently this job has been planned, consider the following:

The hole to be drilled at Stations B and C is equal to part length *(.755)* minus counterbore depth *(.125)*, plus an additional throw to assure the corner of the drill goes past the outboard side of the cutoff tool *(say, .032-inch)*, a total of .662-inch which yields .331-inch required throw if drilling is divided evenly between the two stations.

Referring to boxed information on the layout page it is seen Davenport specifies 3/8-inch cams in these positions, but adjusts their quadrants to yield .91 of total throw:

$.375 \times .91 = .3412$ available throw
$-.331$ required throw
$.0102$ tool approach

In much the same manner, O.D. forming is divided between Stations A and B, followed by roller-rested shave/sizing at C. By calculating the distance from the point of contact to the bottom of the cutoff-starting groove, Davenport determined the circular form tools at Stations A and B should each have .075-inch throw, plus another. 005 for pressure against tool slide positive stops. On that basis, forming operations at these positions were specified to have 3/32-inch cams quadrant-adjusted for 85 percent stroke.

Longest Operation

Part 2 of this series defined the longest operation as the one requiring greatest number of working revolutions. Working revs, in turn, were said to be the product of required tool stroke, divided by assigned feed rate. An exception to that rule was noted in Part 3 where Davenport's Steel Threading Method was said to require six work spindle revs to tap one full thread in and out.

On that basis the 1/2-inch long, 24-pitch tapped section of the part under discussion here will require 6×12, or 72 working revs. Since forming *(at nominal feed of .001)* would require more than 72 revs for an .080-inch throw, we need go no farther than mental arithmetic to know threading will overlap on at least one other operation and is, therefore, not the longest.

The choice, then, boils down to forming in Stations A and B, versus drilling at Stations B and C.

Revs for these operations are so nearly alike that either could be made longest by selecting high or low sides of book-recommended feed rates. Since situations of this sort call for arbitrary decision, Davenport engineers chose to call forming the longest operation and assigned a .0009 i.p.r. feed rate resulting in 88.8 working revs, lengthened to 92 revs on the layout sheet for reasons to be explained later.

Having determined revs needed for the longest operation, feed rates

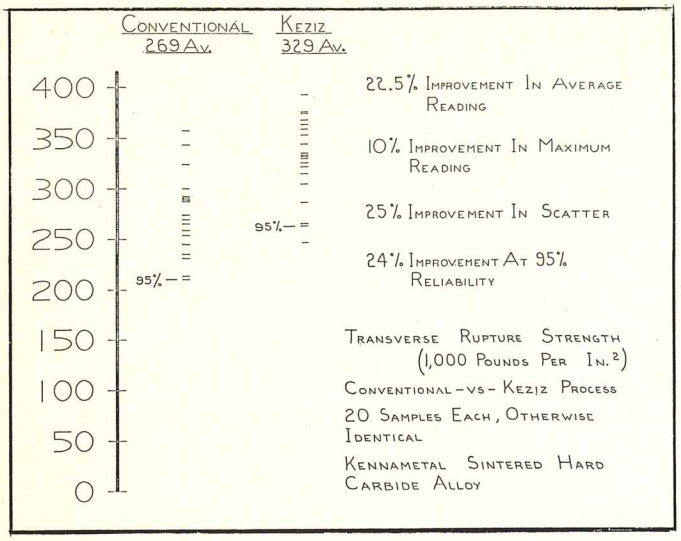


FIGURE 3

ANVIL LOT	PROCESS	VISIBLE PITS/100 IN.²
A 1	CONVENTIONAL	3
A 2	KEZIZ	0
B 1	CONVENTIONAL	11
B 2	KEZIZ	0
C 1	CONVENTIONAL	71
C 2	KEZIZ	0

FIGURE 4

humanly possible.

Sintered hard carbide alloys have near-zero ductility; if loaded to destruction, they will break without noticeable permanent bending. Within their strength limits, they are very stiff, deflecting only 1/3 to 1/2 as much as steel under the same load. These properties are often the reason for selection, but they do result in a high degree of notch sensitivity.

As loading approaches the failure point, even a tiny crack, scratch, pit, or pore can be a starting point for rupture. Cracks and scratches can be prevented; pits and pores have, until now, always been present in sintered carbide alloys. If a defect is at or near a highly stressed surface, it will determine the breaking strength of the loaded part. Thus, the safe usable strength of a part is greatly dependent upon the size, shape, frequency and location of its imperfections.

The Keziz Process reduces the frequency and size of pits and pores, permitting design for higher stress levels, or higher reliability of performance at the same stress level.

To demonstrate the benefits of the method, Kennametal took 40 test specimens and processed half of them by conventional sintering, the other half by Keziz. In Figure 3 each dash on the graph is an individual breaking strength, with 20 dashes in each column.

Average break strengths are shown at the top of the columns. The improvement through use of Keziz is 22.5 percent.

Maximum strength shows an improvement of only 10 percent indicating that Keziz does more for the poorer parts than for the best one. This results is less scatter, pulling the best and worst 25 percent closer together and making the material more predictable. *(Part of the scatter is in the testing method and equipment.)*

Where does it apply? First, consider the cost, inconvenience, and safety involved in a failure. A failed tooth in a rock cutting auger is not critical whereas failure of a petrochemical compressor plunger could result in serious damage, down time, fire and personal risk. It must, therefore, be designed at a reliability level near 100 percent.

Figure 3 represents only 20 tests, but assuming a reliability requirement of 95 percent, the design stress could be at 260,000 p.s.i. instead of 210,000, an increase of 24 percent.

Or, if designing for a stress level of 240,000 p.s.i., reliability could be near 100 percent with Keziz processing, compared to 75 percent without it.

Structural components which can benefit are long-overhang boring bars, grinder spindles or housings, compressor plungers, anvils and dies for ultrahigh pressure apparatus, cold extrusion punches, swaging mandrels.

The other area of application are those requiring a near perfect surface throughout a substantial number of redressings.

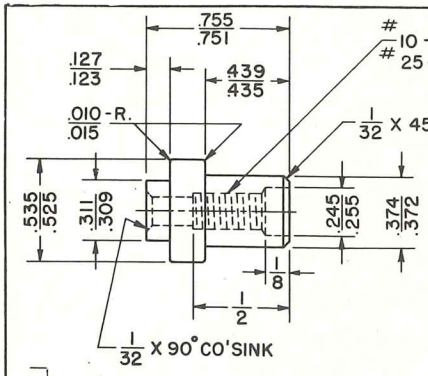
Figure 4 shows what can be accomplished by Keziz Processing, in terms of some anvils requiring defect-free surfaces. Three lots were selected, good, fair and poor; and a portion of each lot processed through Keziz. Considering the pits .003-inch and up as being unacceptable in this item, the new process brought all three lots into a 100 percent acceptable condition.

Rolls for strip or foil mills are a good example of the need for a near perfect surface, original and redressed.

Not all applications of sintered hard carbide alloys require defect-free surfaces. Others must be free of surface defects to function at all, and many fall somewhere between.

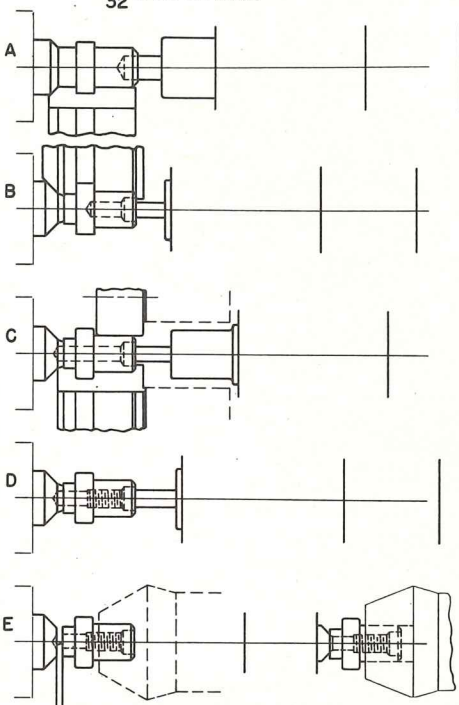
Products which benefit greatly from the Keziz Process surface improvement are draw dies and mandrels, extrusion punches, strip mill rolls, wire flattening rolls, liners and plungers for pumps and compressors, balls for burnishing, sizing or valving, burnishing rolls for railroad axle journals, swaging dies and mandrels.

From a designer's point of view, the Keziz process opens up new fields of application, improves reliability, permits higher safe stresses and assures high surface integrity in components of sintered hard carbide alloys. ■

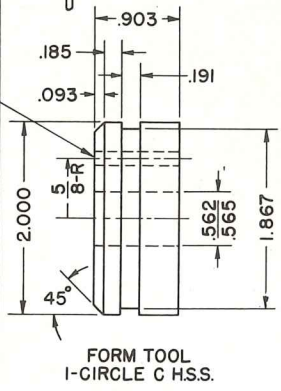


(DOUBLE SIZE)

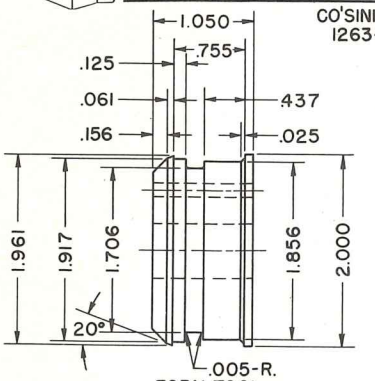
MATERIAL— 9/16" ROUND SAE-1112
151 SURFACE FT. PER MIN.
SPINDLE 1026 R.P.M.—GEARS 26-38
6.4 SEC. PER PIECE 562 AN HOUR GROSS
LESS 20%-EXPECTED NET PRODUCTION PER HOUR 450
FEED GEARS— 60 (72-24 IDLER)
THREAD GEARS— 32-32
SERIAL NO.
MODEL— B - WITH THREADING
CYCLE 75
DATE OF FIRST SHIPMENT



OPERATIONS	TOOLS USED	CAMS USED	FEED OF TOOL	FEED PER REV.	EFFECT-IVE REV.	LOCATION OF BLOCK
STOP STOCK & DRILL .250-DIA.	STOCK STOP E-2904-10 ADJ. DR. HOLDER E-2717	1/4	.220	.0024	92	.88
FORM	CIRCULAR FORM TOOL	3/32	.080	.0009	92	.85
DRILL #25-.1495 DIA.	ADJUSTABLE DRILL HOLDER E-2717	3/8	11/32	.0037	92	.91
FORM	CIRCULAR FORM TOOL	3/32	.080	.0009	92	.85
DRILL #25-.1495 DIA.	ADJUSTABLE DRILL HOLDER E-2717	3/8 FORM	11/32	.0037	92	.91
SIZE	SIZING TOOL HOLDER E-2726-S	3/32	-	-	-	1.
TAP #10-24 NS-2	TAP HOLDER E-2747-C	#4 STEEL	-	-	-	1.2
CUT OFF	BLADE TOOL HOLDER E-2768	1/8	.125	.0013	92	1.
CO'SINK LEFT END	STATIONARY H'D BURR ATT. 1263-5-10-S.A.	SPEC.	.045	.0032	14	-

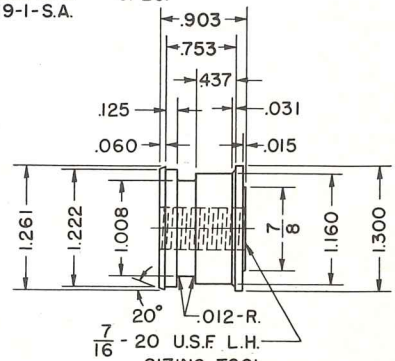


FORM TOOL
1-CIRCLE C H.S.S.



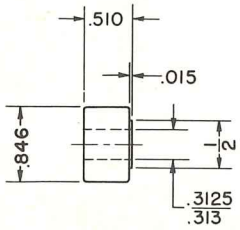
FORM TOOL
1-CIRCLE C H.S.S.

CO'SINK ARM ATT. 1263-119-1-S.A. SPEC.



SIZING TOOL
1-H.S.S.

TOOLS REQUIRED



SIZING TOOL ROLL
1-T.S. HDN.

MARK ALL TOOLS WITH CUSTOMERS PART NUMBER 1

MULTIPLE SPINDLE AUTO. SCR. MACH.

BUSHING

MARCH 3, 1943 W. S.

DAVENPORT MACHINE TOOL CO., INC.

ROCHESTER, N. Y., U. S. A.

No. S-1943-1

DAVENPORT MACHINE TOOL CO.,INC.
MODEL B MACHINE 75 CYCLE - IDLE TIME 2/5 SECOND (.4)
TABLE FOR FEED CHANGE GEARS

WORKING PORTION OF FORMING AND TURNING CAMS EQUALS .50: .05 OF THIS AMOUNT IS FOR DWELL AT THE END OF RISE TO INSURE ACCURACY AND FINISH. TABLE GIVES EFFECTIVE REVOLUTIONS OF WORK SPINDLE DURING .45.

Time in seconds to complete one piece	Gross Production per Hour	Driver (200 R.P.M.)	Driven (Compound)	Driver (Compound)	Driven	R. P. M. SPINDLES																							
						500	587	682	750	841	962	1026	1125	1166	1243	1324	1409	1500	1597	1700	1810	1930	2000	2192	2340	2500	2674	3000	3300	3833	4500
.8	4500	H.S.CLUTCH				3	4	4	5	5	6	6	7	7	7	8	8	8	9	10	10	11	12	12	13	14	15	16	18	20	23	27
1.0	3600	99	30	60	80	4	5	6	7	8	9	9	10	10	11	12	13	14	14	15	16	17	18	20	21	23	24	27	30	34	41
1.1	3275	86	30	60	80	5	6	7	8	9	10	11	12	12	13	14	15	16	17	18	19	20	21	23	25	26	28	32	35	40	47
1.2	3000	75	30	60	80	6	7	8	9	10	12	12	14	14	15	16	17	18	19	20	22	23	24	26	28	30	32	36	40	46	54
1.3	2770	67	30	60	80	7	8	9	10	11	13	14	15	16	17	18	19	20	22	23	24	26	27	30	32	34	36	41	45	52	61
1.3	2770	64	30	60	80	7	8	9	10	11	13	14	15	16	17	18	19	20	22	23	24	26	27	30	32	34	36	41	45	52	61
1.4	2570	60	30	60	80	7	9	10	11	13	14	15	17	17	19	20	21	23	24	25	27	29	30	33	36	38	40	45	50	57	66
1.5	2400	54	30	60	80	8	10	11	12	14	15	16	17	19	21	22	23	25	26	28	30	32	33	36	39	41	44	50	54	63	74
1.6	2250	52	30	60	80	9	11	12	14	15	16	17	18	21	22	24	25	27	29	31	33	35	36	39	42	45	48	54	59	69	81
1.6	2250	50	30	60	80	9	11	12	14	15	16	17	18	21	22	24	25	27	29	31	33	35	36	39	42	45	48	54	59	69	81
1.8	2000	86	USE 60 TOOTH IDLER			10	12	14	16	18	20	22	24	24	26	28	30	32	34	36	38	41	42	46	49	53	56	63	69	80	95
2.0	1800	75				12	14	16	18	20	22	25	27	28	30	32	34	36	36	38	41	43	46	48	53	56	60	64	72	79	92	108
2.2	1635	67				13	16	18	20	23	24	26	28	30	31	34	36	38	41	43	46	49	52	54	59	63	68	72	81	89	103	122
2.3	1565	64				14	17	19	21	24	26	27	29	32	33	35	38	40	43	46	48	52	55	57	62	67	71	76	86	94	109	128
2.4	1500	60				15	18	20	23	25	29	31	34	35	37	40	42	45	48	51	54	58	60	66	70	75	80	90	99	115	135
2.6	1385	54				16	19	23	25	28	32	34	37	38	41	44	46	50	53	56	60	64	66	72	77	83	88	99	109	126	149
2.7	1333	52				17	20	24	26	29	33	35	39	40	43	46	49	52	55	59	62	67	69	76	81	86	92	104	114	132	155
2.8	1285	50				18	21	25	27	30	35	37	41	42	45	48	51	54	58	61	65	69	72	79	84	90	96	108	119	138	162
2.9	1240	48				19	22	26	28	32	34	36	38	42	44	47	50	53	56	60	64	68	72	75	82	88	94	100	113	124	144	169
3.1	1161	44				20	24	28	30	34	36	39	42	46	47	50	54	57	61	65	69	73	76	81	89	95	101	108	122	134	155	182
3.2	1125	43				21	25	29	32	35	38	40	43	47	49	52	56	59	63	67	71	76	81	84	92	98	105	112	126	138	161	189
3.4	1058	40				22	26	31	34	38	41	43	46	51	52	56	60	63	68	72	76	81	87	90	99	105	113	120	135	149	172	203
3.5	1028	39				23	27	32	35	39	42	45	48	52	54	58	62	66	70	74	79	84	90	93	102	109	116	124	140	153	178	209
3.6	1000	38				24	28	33	36	40	43	46	49	54	56	60	64	68	72	77	82	87	93	96	105	112	120	128	144	158	184	216
3.7	973	36				25	29	34	37	42	45	48	51	56	58	62	66	70	74	79	84	90	96	99	109	116	124	132	149	163	190	223
3.9	923	34				26	31	36	39	44	47	51	54	59	61	65	70	74	79	84	89	95	101	105	115	123	131	140	158	173	201	236
4.2	857	32				28	33	39	43	48	51	55	58	64	66	71	75	80	86	91	97	103	110	114	125	133	143	152	171	186	218	257
4.3	837	31				29	34	40	44	49	53	56	60	66	68	73	77	82	88	93	99	106	113	117	128	137	146	156	176	193	224	263
4.4	818	30				30	35	41	45	50	54	58	62	68	70	75	79	85	90	96	102	109	116	120	132	140	150	160	180	198	230	270

for all other work are adjusted to utilize as many of them as possible.

Referring to a book of recommended cutting speeds it will be found that SAE 1112 steel should be run at about 150 s.f.m., which, for 9/16-inch diameter bar stock will require a spindle speed of 1019 r.p.m. A Davenport spindle speed chart shows the nearest set of change gears will yield 1026 r.p.m., or 151 s.f.m. As can be seen from the layout sheet, the 26-38 gear combination was chosen.

Cycle Time

The Feed Gear Change Chart, *(Table 2)* lists the next larger number of working revs *(over 88.8)* in the 1026 r.p.m. column as 92.

| R.P.M. OF SPINDLES | | |

DAVENPORT PRINCIPLES

Basic Instruction: PART 6

THROUGHOUT this series it has been stated that on multiple-spindle automatics all other operations "overlap" on the one requiring greatest number of working revolutions. To reinforce the learning of this fact, examples were given to show how working revs are calculated by dividing work stroke by feed rate. These principles were re-applied in Part 5 where the relatively slow spindle speed needed for steel bar stock resulted in what, for a Davenport, was a rather long cycle time of 6.4-seconds.

The brass workpiece seen on the facing page and featured in this installment requires almost as many revs as the previous layout *(90 here, compared to 92 there)*, yet its cycle time is just slightly more than one-third as long *(2.4 vs. 6.4 seconds)*. Moreover, the piece described here is about twice longer, thereby offsetting any feed rate advantages that might occur due to use of non-ferrous bar stock.

What, then, makes this job so much faster than the pervious one? The answer is machinability of material. The 150 s.f.m. cutting rate dictated by 1112 steel required the cycle be calculated on the basis of time required to complete working revs at 1026 r.p.m. spindle speed.

The brass job featured here imposes no such restriction. On Davenport automatics brass is routinely run at top spindle speed *(3,000 r.p.m.)*, meaning that, *all else being equal,* cycle time for this part would be about two thirds faster than if the material were 1112 steel.

While the contrast is most apparent in a steel vs. brass situation such as this, as similar if somewhat smaller gain often can be obtained by substituting a "free-machining" grade of steel for one with lower machinability rating or by switching to a type of cutting tool which can withstand greater heat. Either way the productivity gain is a direct result of conditions which allow spindle speeds to be increased without decreasing "edge life" *(the number of parts produced per tool sharpening)*.

Layout Analysis

Once again the machine is a five-spindle, 75-cycle Model B Davenport with threading capability in Fourth Position, and a synchronized Burring Attachment in Fifth.

Spindle speed of 3,000 r.p.m. yields 445 s.f.m. on the .577-inch across-corner diameter for half-inch hex brass rod.

Finish turning, at Station C is the longest operation, requiring 90 revs at .009 i.p.r. to complete an .809/.815-inch cut delivered by a 7/8-inch cam adjusted to yield 92 percent of stroke.

Using the feed gear chart from the Davenport Instruction book *(Table 2 in Part 5 of this series)*, follow down in the 3000 r.p.m. column to 90 revs, then left to find change gears, hourly net and gross production, and cycle time: 2.4 seconds.

As shown on the layout, the hex bar is hollow milled at Station A in a heavily-fed pass intended primarily to de-corner material. At Station B the head, thread blank and thread neck are formed while the outer end is faced to 5/16-inch radius. Finish turning at Station C brings the outboard stem to .309/.311 tolerance and smooth finish.

In topmost Station D, a die head is run on at differential speed, then popped open. Since there are no more than eight threads on the part, it becomes academic whether the open die head is returned in rapid traverse or at conventional Steel Threading rate. In either instance a maximum of 48 revs are easily superimposed on the 90 needed for the longest operation.

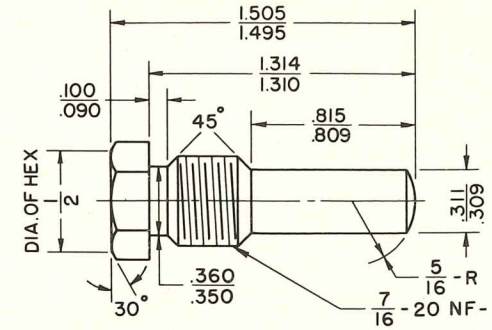
Conceivably this workpiece could have been run on a Plain *(non-threading)* Model B Davenport by mounting a non-rotating self-opening die head in the Fourth Position tool spindle. Doing so, however, would have been equivalent to Davenport's Brass Threading Method, which limits work spindle speed to 2500 r.p.m. Another, much less restrictive plan would be to produce the thread with a thread rolling attachment *(Figure 18)*. The device is a Davenport-patented holder which moves opened thread rolls to bar center, then causes them to "pinch" the work blank to roll threads in less revolutions than would be possible any other way.

In final Station E the part is gripped in a pickoff collet running at spindle speed to provide outboard support while the cutoff tool goes slightly past center to give a clean, burr-free back end. Note the .0022 i.p.r. feed rate for cutting off utilizes the full 90 working revs needed for finish turning in this situation where no revs are required for back counterboring.

Summary:

Words and pictures, no matter how explicit, are a poor substitute for first-hand experience. The information in these six articles is, at best, merely an orientation for further study.

Those with access to a Davenport automatic will have grasped the descriptions more readily than those who have not had opportunity to see for themselves the actual working out of concepts.



(DOUBLE SIZE)

MATERIAL— 1/2" - HEX BRASS ROD

445 SURFACE FT. PER MIN.

SPINDLE 3000 R.P.M.—GEARS 42 - 21

2.4 SEC. PER PIECE 1500 AN HOUR GROSS

LESS 20 %-EXPECTED NET PRODUCTION PER HOUR 1200

FEED GEARS— 60 (60 - IDLER)

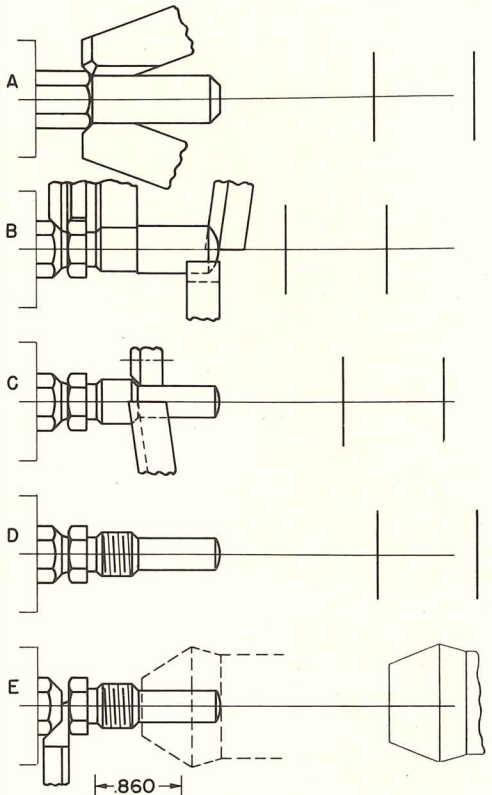
THREAD GEARS— 34 - 30

SERIAL NO.

MODEL— B - WITH THREADING

CYCLE 75

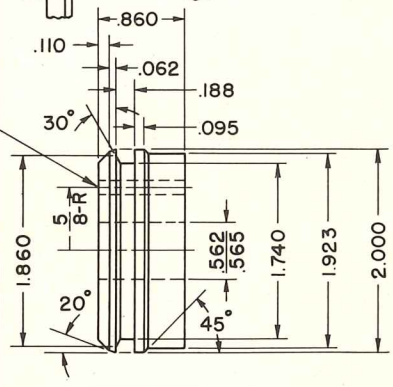
DATE OF FIRST SHIPMENT



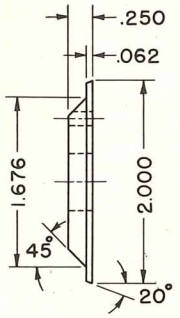
OPERATIONS	TOOLS USED	CAMS USED	FEED OF TOOL	FEED PER REV.	EFFECT-IVE REV.	LOCATION OF BLOCK
STOP STOCK & ROUGH TURN	STOCK STOP E-2810 ADJ. HOLLOW MILL	1 1/4	1 3/16	.0132	90	.94
FACE RADIUS	BOX TOOL E-2700-4	1/8	.100	.0011	90	.8
FORM	CIRCULAR FORM TOOL	1/8	1/8	.0014	90	1.
FINISH TURN	BOX TOOL E-2785-1	7/8	13/16	.009	90	.92
REVOLVE DIE HEAD 2550-R.P.M.						
THREAD	SELF OPENING DIE HEAD	3/4	-	-	-	.9
CUT OFF WITHOUT BURR	CIRCULAR CUT OFF TOOL	1/4	.200	.0022	90	.8

STATIONARY HEAD BURRING ATT. 1263-5-10-S.A.

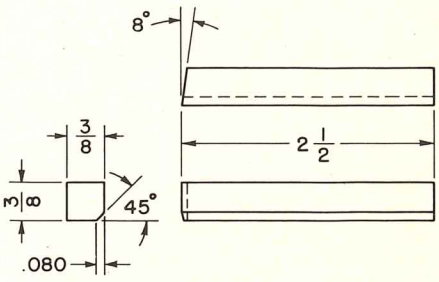
3 - .140 HOLES 120° APART



FORM TOOL
1 - H.S.S.

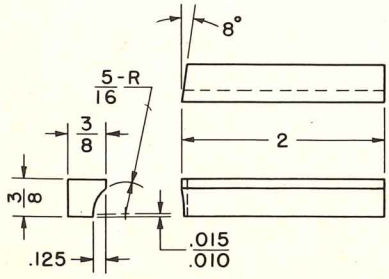


CUT OFF TOOL
1 - H.S.S.



BOX TOOL BLADE
1 - H.S.S.

TOOLS REQUIRED



BOX TOOL BLADE
1 - H.S.S.

MARK ALL TOOLS WITH CUSTOMERS PART NUMBER 2

MULTIPLE SPINDLE AUTO. SCR. MACH.

ADJUSTING SCREW

DAVENPORT MACHINE TOOL CO., INC.

ROCHESTER, N. Y., U. S. A.

No. B-1943-2

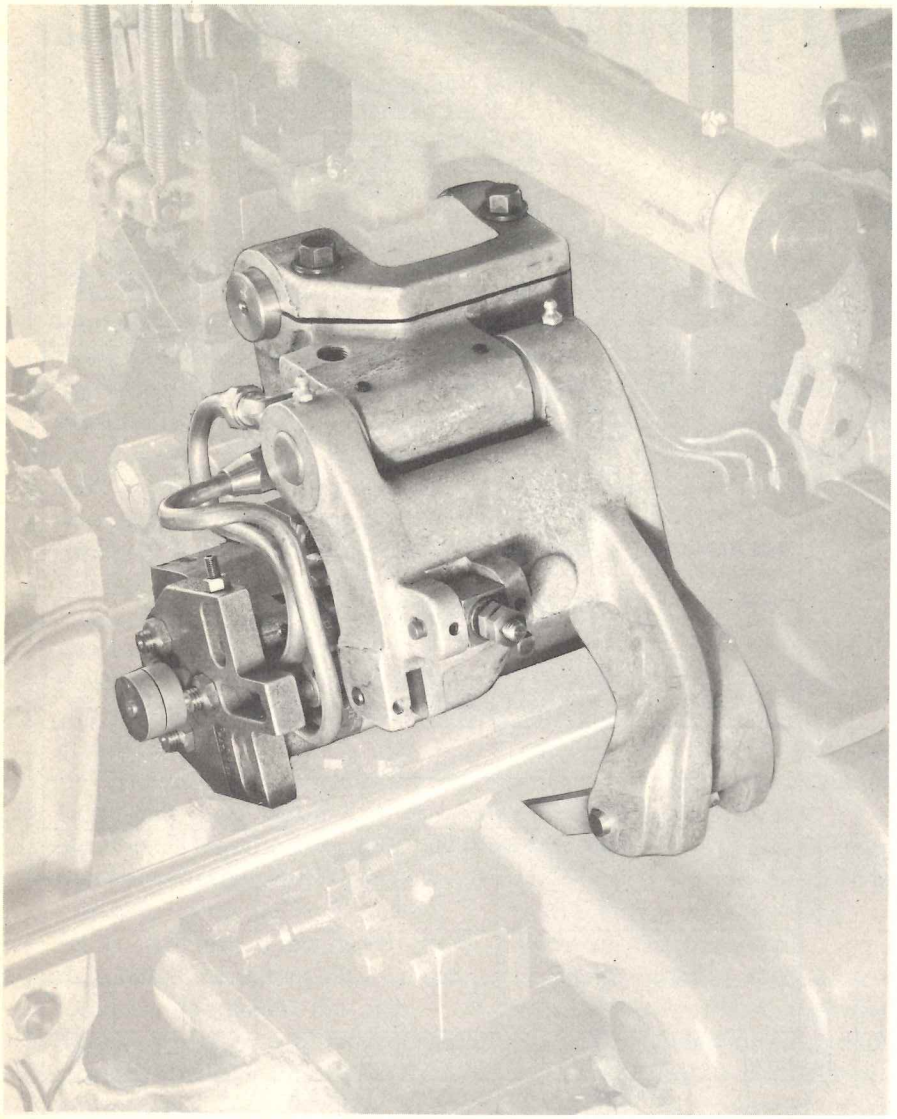


FIGURE 18

Nor has this series by any means exhausted the written information. Those who wish to delve more deeply can begin by obtaining the two references against which the information in this series was checked: Davenport's *Model B Instruction Book, Sixth Edition,* and a pictorial catalog titled, *Davenport Multiple-Spindle Automatic Screw Machines.*

Leafing through either booklet will show this six-part series has omitted as much as was covered, has oversimplified in some instances, and in others may have overemphasized the obvious.

If, however, the words and illustrations which have been included should stir even a few to investigate career opportunities as Davenport operators, setup men, estimators, or tooling specialists, the series will have accomplished its purpose.

In that event, both the reader and the screw machine industry will have benefited.

Next issue, a bonus installment of this series will present part prints and layouts for three additional Davenport jobs. ■